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**Information Analysis Center Contributions to**

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**DoD KEY TECHNOLOGIES  
Volume II of IV**

**DoD IAC Conference  
Orlando, Florida  
October 7-8, 1993**

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Information Analysis Center**

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## Preface

The Department of Defense has established the DoD Information Analysis Centers (IAC) program as part of the DoD Scientific and Technical Information Program. IACs exist to assist users in making best use or application of existing scientific, technical and related information. In so doing, the 23 chartered DoD IACs and the Service or Component sponsored information centers save scarce DoD scientific and technical resources, prevent unnecessary duplication of effort among DoD components, and provide additional technical assistance to DoD components, other U.S. Government agencies and departments, their contractors, and other qualified users. The table on the following pages lists the Information Centers and the Point of Contact for each one.

This volume summarizes in unclassified unlimited distribution format, work performed by DoD Information Analysis Centers for DoD or other U.S. Government sponsors which has application over and beyond the immediate requirement to which the IACs responded. Readers are advised that much of the specific work, the resulting data, and interim or final reports described herein may be classified or otherwise withheld from general distribution in accordance with appropriate statute and/or DoD regulations. On balance, however, it is appropriate that DoD IACs share with their broadest user communities the results of data and information collection efforts, efforts to maintain and develop analytical tools and techniques, and the results of detailed studies and analyses of scientific, technical and related problems. These results are often applicable to problems which extend beyond the narrow focus of DoD, and can be described in terms that compromise no classified or sensitive information.

The DoD IAC Program has access to DoD's investment in science and technology spanning the past 40 years. It has access to the analytical tools and techniques which DoD has used to assess this information. The scientific and technical challenges facing the nation go well beyond the boundaries of the DoD IAC Program; the efforts of DoD IACs described at least in part in this volume illustrate the potential contributions IACS could make. Potential users, inside or outside the executive branch of the U.S. Government are encouraged to contact IACs of interest or the DoD IAC Program Management Office to obtain additional assistance or to make use of the knowledge and skills resident within this program.

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## INFORMATION CENTERS

DoD Information Analysis Centers		
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CBIAC	Chemical Warfare/Chemical and Biological Defense Information Analysis Center	Mr. James J. McNeely Phone: (410) 676-9030 E-Mail: <a href="mailto:jjmcneel@im.battelle.org">jjmcneel@im.battelle.org</a>
CEIAC	Coastal Engineering Information Analysis Center	Dr. Fred Camfield Phone: (601) 634-2012 E-Mail: <a href="mailto:camfield@coafs1.wes.army.mil">camfield@coafs1.wes.army.mil</a>
CIAC	Ceramics Information Analysis Center	Dr. C. Y. Ho Phone: (317) 494-9393 Dr. Said K. El-Rahaiby Phone: (317) 494-9393 E-Mail: <a href="mailto:rahaiby@ecn.purdue.edu">rahaiby@ecn.purdue.edu</a>
CPIA	Chemical Propulsion Information Agency	Mr. Thomas W. Christian Phone: (410) 992-7300 E-Mail: <a href="mailto:cpial_tc@jhunix.hcs.jhu.edu">cpial_tc@jhunix.hcs.jhu.edu</a>
CRSTIAC	Cold Regions Science and Technology Information Analysis Center	Ms. Nancy Liston Phone: (603) 646-4221 E-Mail: <a href="mailto:nliston@hanover-cirrel.army.mil">nliston@hanover-cirrel.army.mil</a>
CSERIAC	Crew System Ergonomics Information Analysis Center	Dr. Lawrence D. Howell Phone: (513) 255-4842 E-Mail: <a href="mailto:lhowell@falcon.aamrl.wpafb.af.mil">lhowell@falcon.aamrl.wpafb.af.mil</a>
CTIAC	Concrete Technology Information Analysis Center	Phone: (601) 634-3264



### DoD Information Analysis Centers (Continued)

DACS	Data and Analysis Center for Software	Mr. Dennis J. Wesolowski Phone: (315) 734-3696 E-Mail: dennisw@kaman.com
DASIAC	DoD Nuclear Information and Analysis Center	Phone: (703) 329-7123 E-Mail: claire-watson@bob.kaman.com
GACIAC	Guidance and Control Information Analysis Center	Dr. Robert J. Heaston Phone: (312) 567-4519 E-Mail: rheaston@dgis.dtic.dla.mil
HEIAC	Hydraulic Engineering Information Analysis Center	Phone: (601) 634-2608
HTMIAC	High Temperature Materials Information Analysis Center	Dr. C. Y. Ho (317) 494-9393 Dr. Ronald H. Bogaard Phone: (317) 494-9393 E-Mail: bogaard@ecn.purdue.edu
IRIA	Infrared Information Analysis Center	Dr. Rodney C. Anderson Phone: (313) 994-1200, Ext. 2725 E-Mail: anderson@erim.org
MIAC	Metals Information Analysis Center	Dr. C. Y. Ho Phone: (317) 494-9393 Dr. Pramod D. Desai Phone: (317) 494-9393 E-Mail: desaip@ecn.purdue.edu
MMCIAC	Metal Matrix Composites Information Analysis Center	Dr. C. Y. Ho Phone: (317) 494-9393 E-Mail: hocy@ecn.purdue.edu Dr. Harvey M. Berkowitz Phone: (317) 494-9393

### DoD Information Analysis Centers (Continued)

<b>MTIAC</b>	<b>Manufacturing Technology Information Analysis Center</b>	<p>Ms. Michal Safar  Phone: (312) 567-4733  E-Mail: msafar@dgis.dtic.dla.mil</p>
<b>NTIAC</b>	<b>Nondestructive Testing Information Analysis Center</b>	<p>Dr. George A. Matzkanin  Phone: (512) 263-2106  E-Mail: ntiac@access.texas.gov</p>
<b>PLASTEC</b>	<b>Plastics Technical Evaluation Center</b>	<p>Mr. Charles Yearwood  Phone: (201) 724-4222  E-Mail: yearwood@pica.army.mil</p>
<b>RAC</b>	<b>Reliability Analysis Center</b>	<p>Mr. Preston MacDiarmid  Phone: (315) 337-0900  E-Mail: rac@mail.itri.com</p>
<b>SMIAC</b>	<b>Soil Mechanics Information and Analysis Center</b>	<p>Mr. David R. Haulman  Phone: (601) 634-3376</p>
<b>SURVIAC</b>	<b>Survivability/Vulnerability Information Analysis Center</b>	<p>Mr. John Vice  Phone: (513) 255-4840  E-Mail: vice@isi.edu</p>
<b>TWSTIAC</b>	<b>Tactical Warfare Simulation and Technology Information Analysis Center</b>	<p>Dr. Larry W. Williams  Phone: (614) 424-5047  E-Mail: williaml@battelle.org  Mr. Ernie Smart  (Distributed Interactive Simulation)  Phone: (407) 658-5014  E-Mail: esmart@dmso.dtic.dla.mil</p>

Service Sponsored Information Centers		
SAVIAC	Shock and Vibration Information Analysis Center	Mr. Hal Kohn Phone: (703) 412-7856 E-Mail: kohn@ccity.ads.com
ASIAC	Aerospace Structures Information and Analysis Center	Mr. Gordon Negaard Phone: (513) 255-6688 E-Mail: asiac@sltvcl.flight.wpafb.af.mil
SIDAC	Supportability Investment Decision Analysis Center	Mr. Kevin Deal Phone: (513) 258-6711 E-Mail: kdeal@bclcll

## Foreword to Volume II

The Department of Defense adopted a new acquisition strategy in the early 1990s. This strategy seeks to preserve the technology base while deferring decisions with regard to the acquisition of military systems until specific threats, roles, mission, and functions requiring new technology have been identified. As part of this strategy, DoD has enumerated eleven specific areas of science and technology which contain special technical challenges on the critical paths of future technology developments of major significance to DoD. Known as DoD Critical Technologies, these include the following:

- Computers
- Software
- Sensors
- Communications Networking
- Electronic Devices
- Environmental Effects
- Materials and Processes
- Energy Storage
- Propulsion and Energy Conversion
- Design Automation
- Human System Interfaces

Successful development of new military and related technologies will depend on meeting and overcoming the special technical challenges found in each of these sets of science and technology.

The DoD Information Analysis Centers (IAC) Program oversees 23 IACs and sponsors 15 contractor operated IACs. Each of the DoD acquisition endeavors listed above is the focus of some information collection, synthesis, analysis, or analytical tool maintenance or development by one or more DoD IAC.

This volume describes work completed by DoD IACs over the past 24 months relevant to DoD Critical Technologies. As noted in the Preface, much of the work completed is not generally available outside the Department of Defense or the U.S. Government. The raw data, the reduced data, and the analytical techniques used to collect or assess such information may be available. Interested readers are encouraged to contact the IAC reporting results of interest and/or the DoD IAC Program Management Office for additional information.

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	IRIA	Air Superiority and Global Surveillance: Shipboard Infrared Search and Track Sensors		
	TWSTIAC	Assessment of Ultra-Wideband (UWB) Radar Technology		
	CRSTIAC	Observations of Acoustic Surface Waves Propagating Above a Snow Cover		
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	<b>CIAC</b>	<b>Assessment of the Status of Ceramic Matrix Composites Technology in the United States and Abroad</b>
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	<b>CPIA</b>	<b>Rocket Motor Manual: One of CPIA's Standard Manuals Directed to the Key DoD Technology on Energy Storage</b>
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<b>DoD Military Forces, Roles, Missions, and Functions</b> Each Military Force, Role, Mission and Function is in a separate section. Each section begins with a blue divider page.		
<b>Military Force, Role, Mission, &amp; Function</b>	<b>IAC</b>	<b>Presentation</b>
<b>Ground Combat Forces (Continued)</b>	<b>GACIAC</b>	<b>Advanced Land Combat</b>
	<b>GACIAC</b>	<b>Tactical Land Forces</b>
	<b>MIAC</b>	<b>Computerization of Properties of Austempered Ductile Iron (ADI)</b>
	<b>MIAC</b>	<b>Failure Analysis on Electroslag Remelt (ESR) 4340 Steel</b>
	<b>NTIAC</b>	<b>Nondestructive Evaluation Applications for Strategic Forces and Missions</b>
	<b>NTIAC</b>	<b>Nondestructive Test/Evaluation Assessment in Support of Tactical Land Forces and Missions</b>
	<b>SURVIAC</b>	<b>Survivability Systems Master Plan</b>
	<b>SURVIAC</b>	<b>U.S. Air Force Surface-to-Air Engagements During Operation Desert Storm</b>
	<b>TWSTIAC</b>	<b>Evaluation of Candidate Warheads Against Chemical Targets for Patriot PAC-3</b>
	<b>TWSTIAC</b>	<b>TWSTIAC Casualty Reduction Modeling for the Natick RD&amp;E Center</b>

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<b>Ground Combat Forces (Continued)</b>	<b>TWSTIAC</b>	<b>TWSTIAC Technology Assessment Program for JSSAP/Small Arms Master Plan (SAMP)</b>
<b>Logistics</b>	<b>CBIAC</b>	<b>Evaluation of Lightweight Integrated Suit Technologies (LIST) and Associated Test Methods</b>
	<b>CSERIAC</b>	<b>Crew System Ergonomics Information Analysis Center (CSERIAC) Products &amp; Services -- Advanced Human System Interface Design in Control Rooms</b>
	<b>CSERIAC</b>	<b>Crew System Ergonomics Information Analysis Center (CSERIAC) Products &amp; Services -- Integrated Maintenance Information System (IMIS): Defined</b>
	<b>CSERIAC</b>	<b>Crew System Ergonomics Information Analysis Center (CSERIAC) Products &amp; Services -- Human Factors in the Design of Synthetic Environments</b>
	<b>DACS</b>	<b>Open Architecture Systems for Process Automation (OASYS)</b>
	<b>MTIAC</b>	<b>Academic Apparel Research Technical Support and Products for DLA</b>
	<b>NTIAC</b>	<b>Quantitative Nondestructive Evaluation (NDE) Data Book</b>

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<b>Military Force, Role, Mission, &amp; Function</b>	<b>IAC</b>	<b>Presentation</b>
<b>Logistics (Continued)</b>	<b>RAC</b>	<b>Reliable Application of Components Series</b>
	<b>RAC</b>	<b>Failure Mode/Mechanism Distributions</b>
	<b>RAC</b>	<b>Time Stress Measurement Device (TSMD)</b>
	<b>RAC</b>	<b>Total Quality Management (TQM) Toolkit</b>
	<b>SURVIAC</b>	<b>Computer-Based Aircraft Wiring Maintenance Aid</b>
<b>Training</b>	<b>CBIAC</b>	<b>Interactive Decision Training Scenario for USN Damage Control and CBR-D Decision Training</b>
	<b>CRSTIAC</b>	<b>Waterfowl Mortality in Eagle River Flats, Alaska</b>
	<b>CSERIAC</b>	<b>Crew System Ergonomics Information Analysis Center (CSERIAC) Products &amp; Services -- Advanced Human System Interface Design in Control Rooms</b>
	<b>CSERIAC</b>	<b>Crew System Ergonomics Information Analysis Center (CSERIAC) Products &amp; Services -- Human Factors Issue in Personnel Training: Potpourri</b>
	<b>CSERIAC</b>	<b>Crew System Ergonomics Information Analysis Center (CSERIAC) Products &amp; Services -- Human Factors in the Design of Synthetic Environments</b>

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<b>Training (Continued)</b>	<b>TWSTIAC</b>	<b>Computers &amp; Software Communications Networking</b>
<b>Arms Control</b>	<b>CBIAC</b>	<b>Bio Technology: A Survey of Seven Technologies to Identify Clostridium Botulinum and Bacillus Anthracis</b>
	<b>CBIAC</b>	<b>Chemical Warfare Counter Proliferation Computerized Decision Aid</b>
	<b>CBIAC</b>	<b>Commercial Products From Demilitarization Operations</b>
	<b>IRIA</b>	<b>Strategic Forces and Arms Control: Infrared Signature Computer Codes</b>
	<b>IRIA</b>	<b>Strategic Forces and Arms Control: "Open Skies" Support</b>
<b>Dual Use</b>	<b>CBIAC</b>	<b>Bio Technology: A Survey of Seven Technologies to Identify Clostridium Botulinum and Bacillus Anthracis</b>
	<b>CBIAC</b>	<b>Chemical Warfare Counter Proliferation Computerized Decision Aid</b>
	<b>CBIAC</b>	<b>Commercial Products From Demilitarization Operations</b>
	<b>CRSTIAC</b>	<b>Waterfowl Mortality in Eagle River Flats, Alaska</b>

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<b>Military Force, Role, Mission, &amp; Function</b>	<b>IAC</b>	<b>Presentation</b>
<b>Dual Use (Continued)</b>	<b>CSERIAC</b>	<b>Crew System Ergonomics Information Analysis Center (CSERIAC) Products &amp; Services -- Advanced Human System Interface Design in Control Rooms</b>
	<b>CSERAC</b>	<b>Crew System Ergonomics Information Analysis Center (CSERIAC) Products &amp; Services -- Integrated Maintenance Information system (IMIS): Defined</b>
	<b>DACS</b>	<b>DACS Technical Reports</b>
	<b>DACS</b>	<b>Open Architecture Systems for Process Automation (OASYS)</b>
	<b>HEIAC</b>	<b>Dam Break Analyses</b>
	<b>HTMIAC</b>	<b>High Temperature Materials Properties Online Numeric Database Capability for Dual-Use Technology Transfer</b>
	<b>NTIAC</b>	<b>Nondestructive/Non-Intrusive Sensors for Manufacturing Process Control</b>
	<b>RAC</b>	<b>Concurrent Engineering Series</b>

## CONTENTS

### Volume IV of IV

This compilation is Limited Distribution, therefore, not all attendees will receive this volume.

#### Product Listings

This compilation lists products from the IACs in the following sequence: those that are relevant to the DoD S&T Thrusts, the Key Technologies, and Military Forces, Roles, Missions, and Functions. Each product is described in terms of: IAC Product Identification Number, Primary Author Name(s), Title, Publication Date, and Available From. Registered users can acquire documents having AD Numbers from the Defense Technical Information Center (DTIC). Please contact the particular IAC to determine the availability of documents which do not have AD Numbers.

CBIAC

CIAC

CPIA

CSERIAC

DACS

HEIAC

HTMIAC

IRIA

MIAC

MMCIAC

RAC

SURVIAC

TWSTIAC

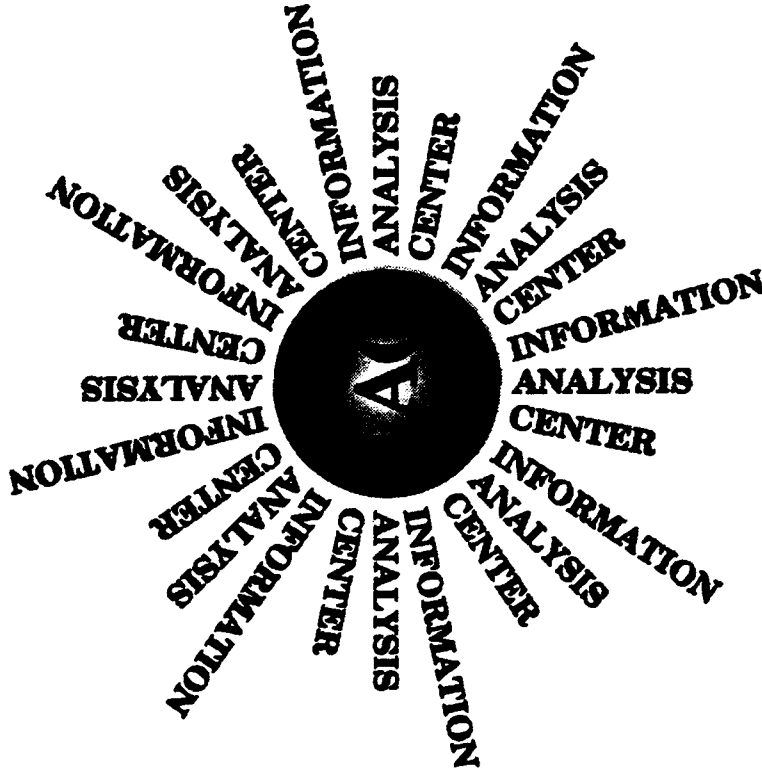


**DoD INFORMATION ANALYSIS CENTER (IAC) PROGRAM**



Defense Technical Information Center • IAC Program

## **DoD Information Analysis Center (IAC) Program**

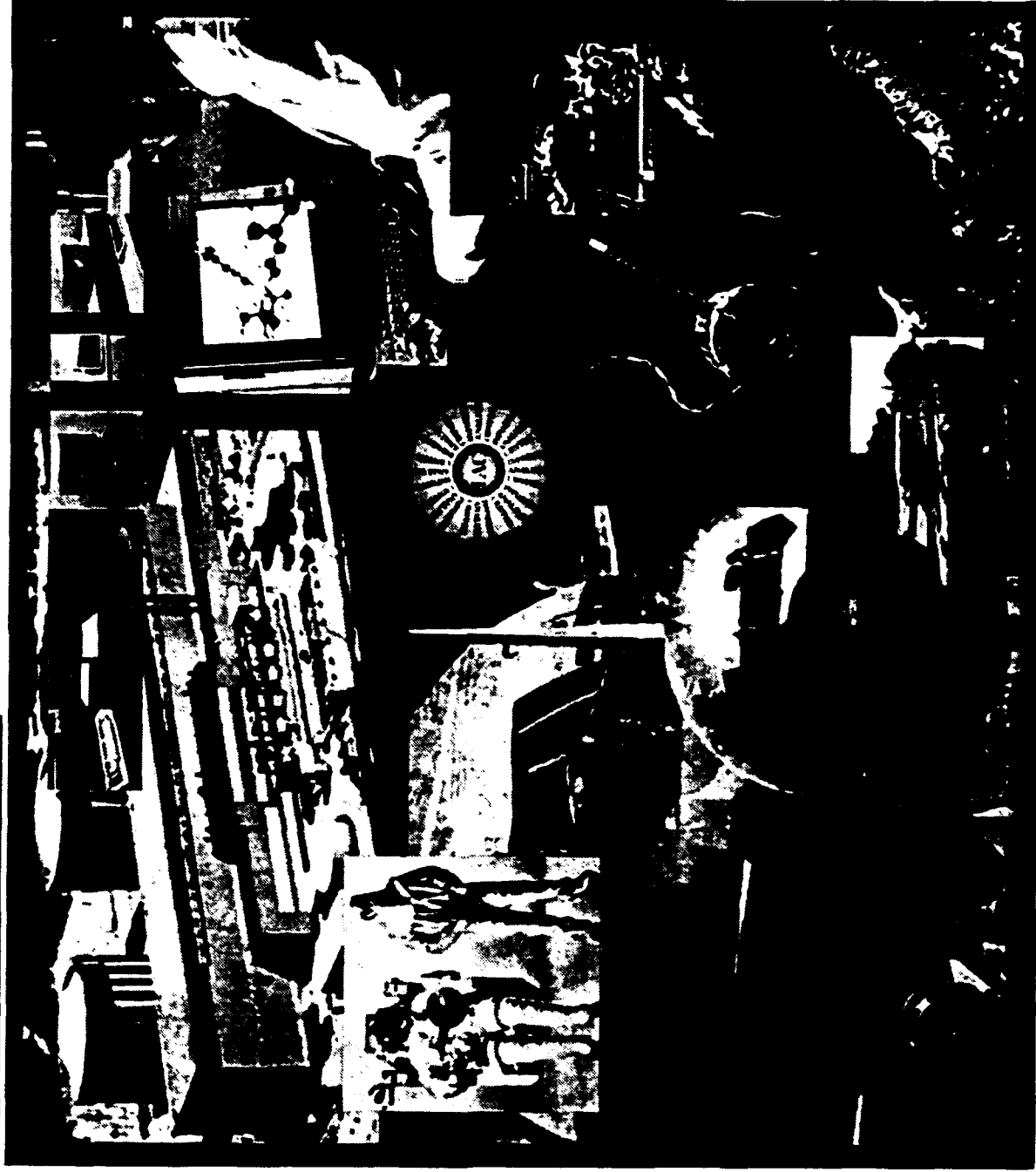


**Presentation by:**  
**Forrest R. Frank**  
**Program Manager, DoD IAC Program**

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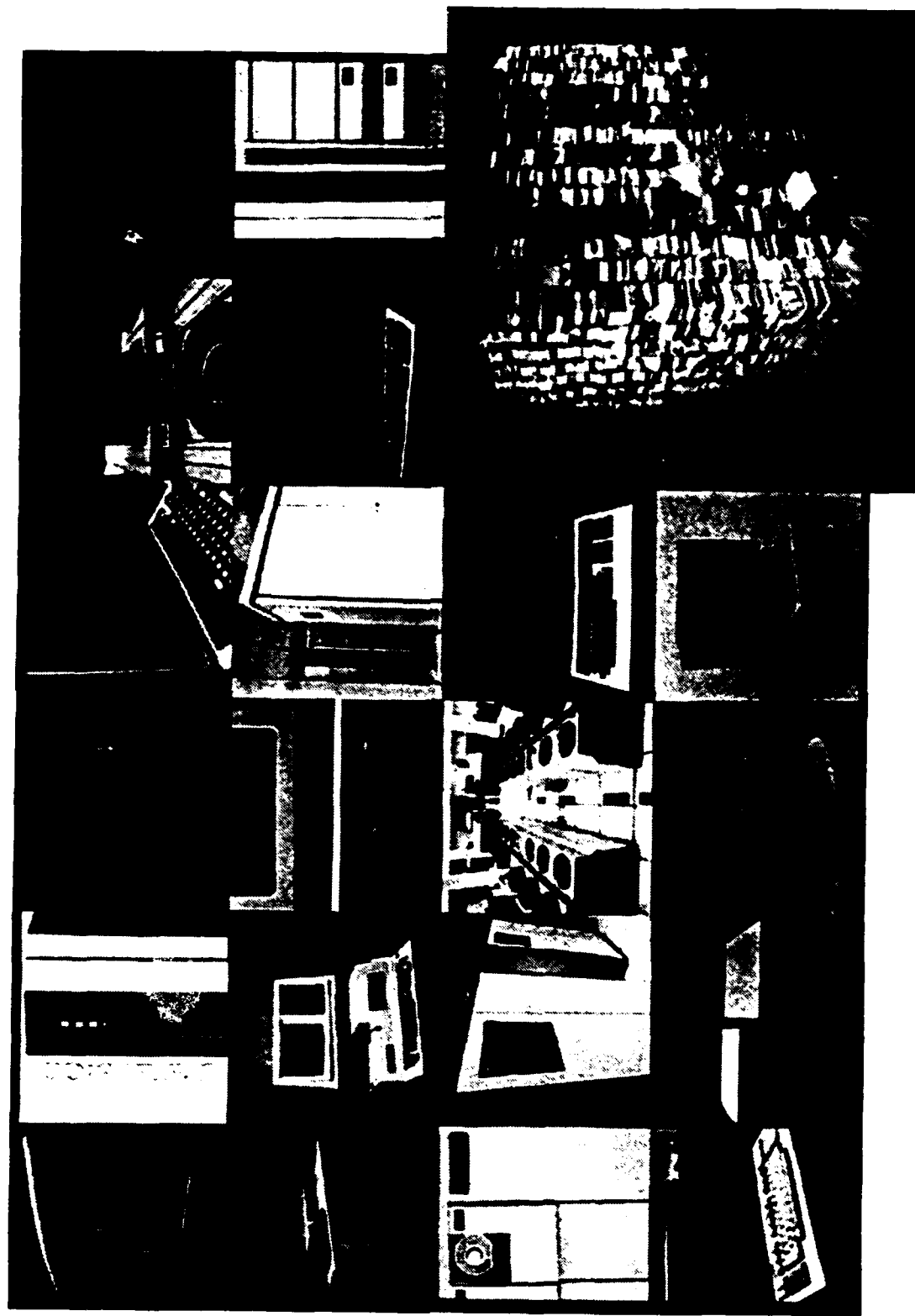
# DoD Information Analysis Center (IAC) Program



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## **Extraneous Information**



## ***Information Overload***



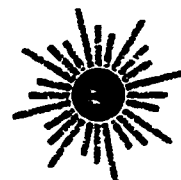
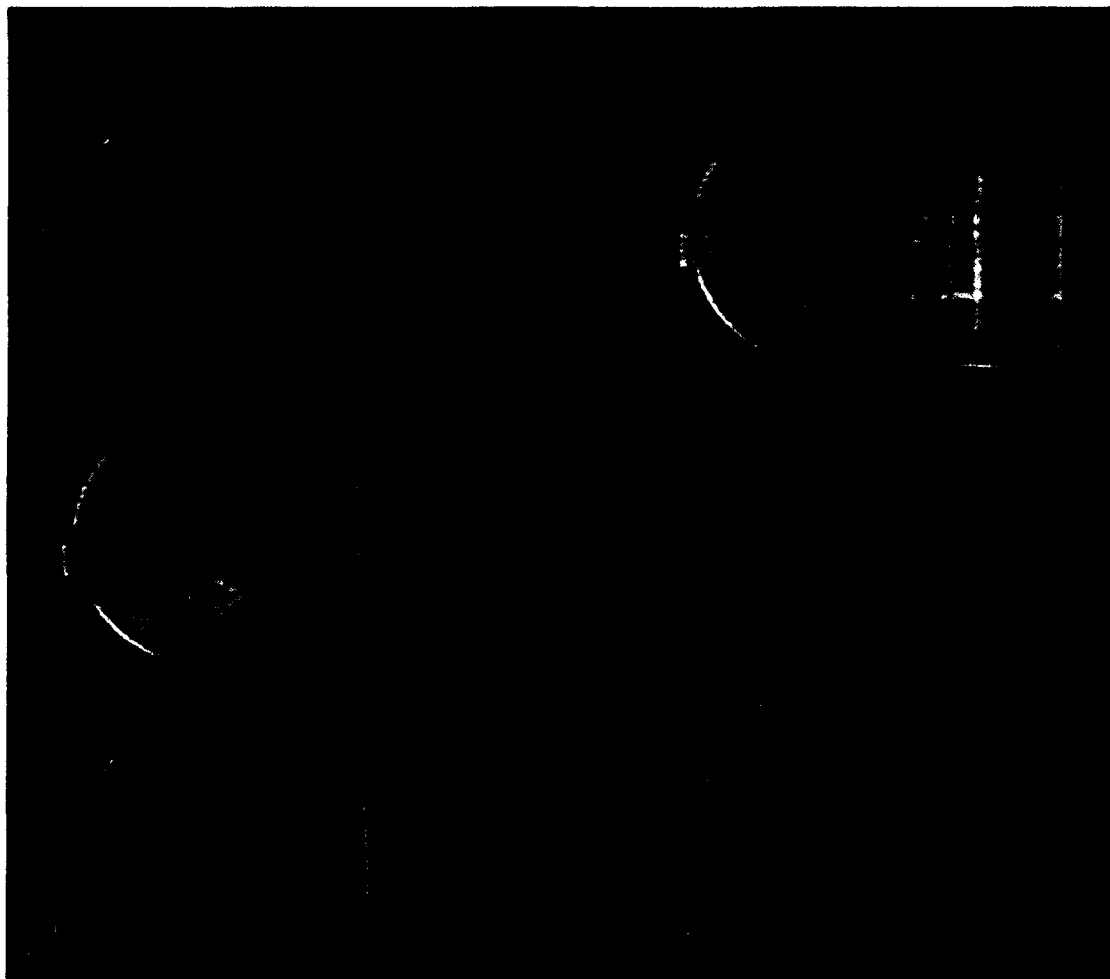
- ***Identify Relevant Data***
- ***Reduce Relevant Data to Information***
- ***Identify and Employ Appropriate Analytical Tools and Techniques***



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## **Can It Be This Simple Again?**



## ***Briefing Overview***

---

- **Mission of IACs**
- **Authority**
- **IAC Functions**
- **IAC Operations**
- **IAC Products and Services**
- **Subject-Matter Coverage**
- **Using DoD IACs**
- **Benefits of IACs**



**Authority**

- **Formal Organization Chartered by DoD
  - DoD Regulation 3200.12-R-2**
- **Staffed by Technical Experts**
- **Co-Located Laboratories and/or Other Technical Activities**
- **Collect and Disseminate Scientific and Technical Information**
- **Provide STINFO Support to DoD, Other U.S. Government Agencies, and Other Authorized Users**

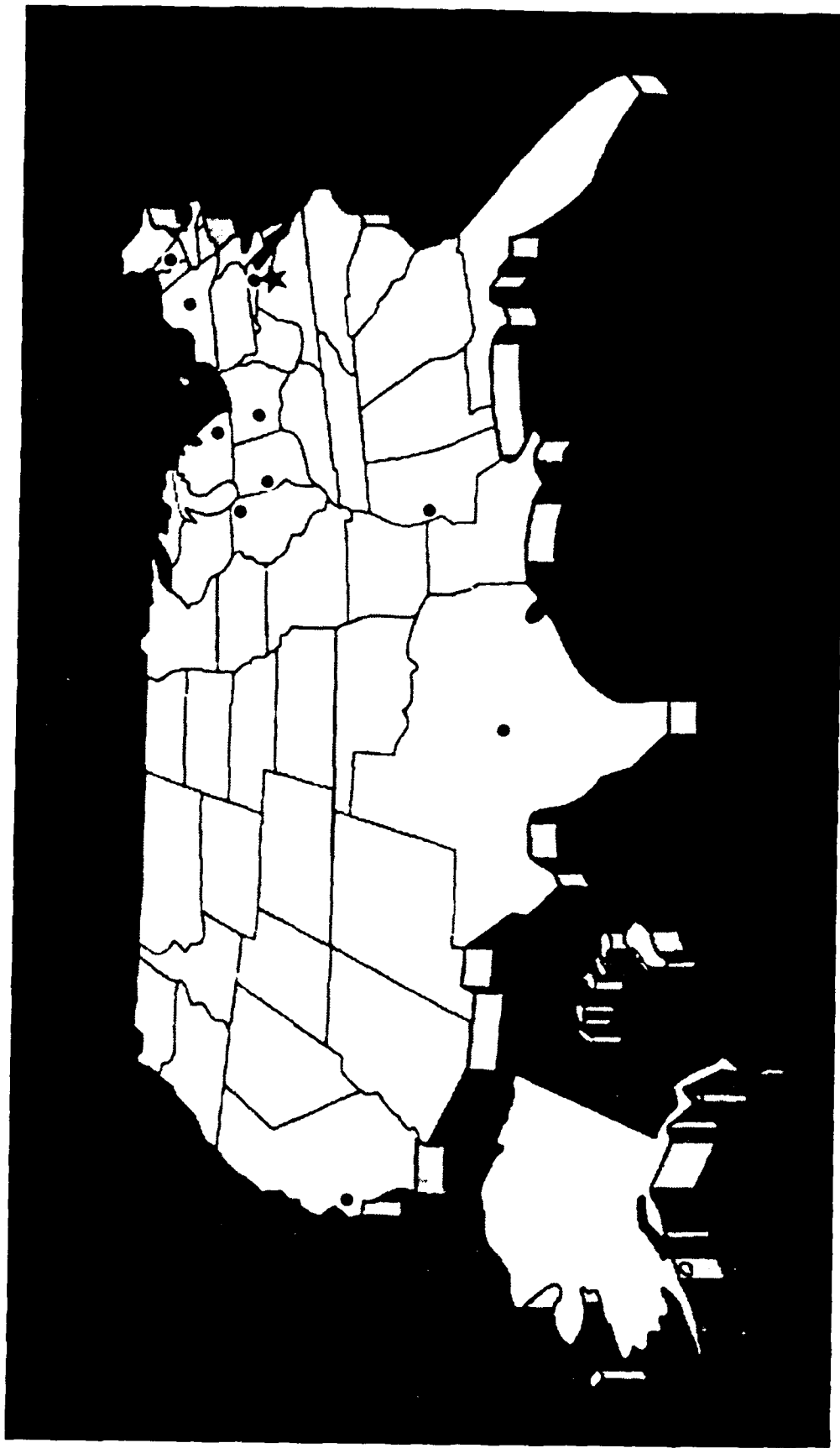




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## **DoD Operates 23 IACs**



## **DoD IACs - Some Examples**

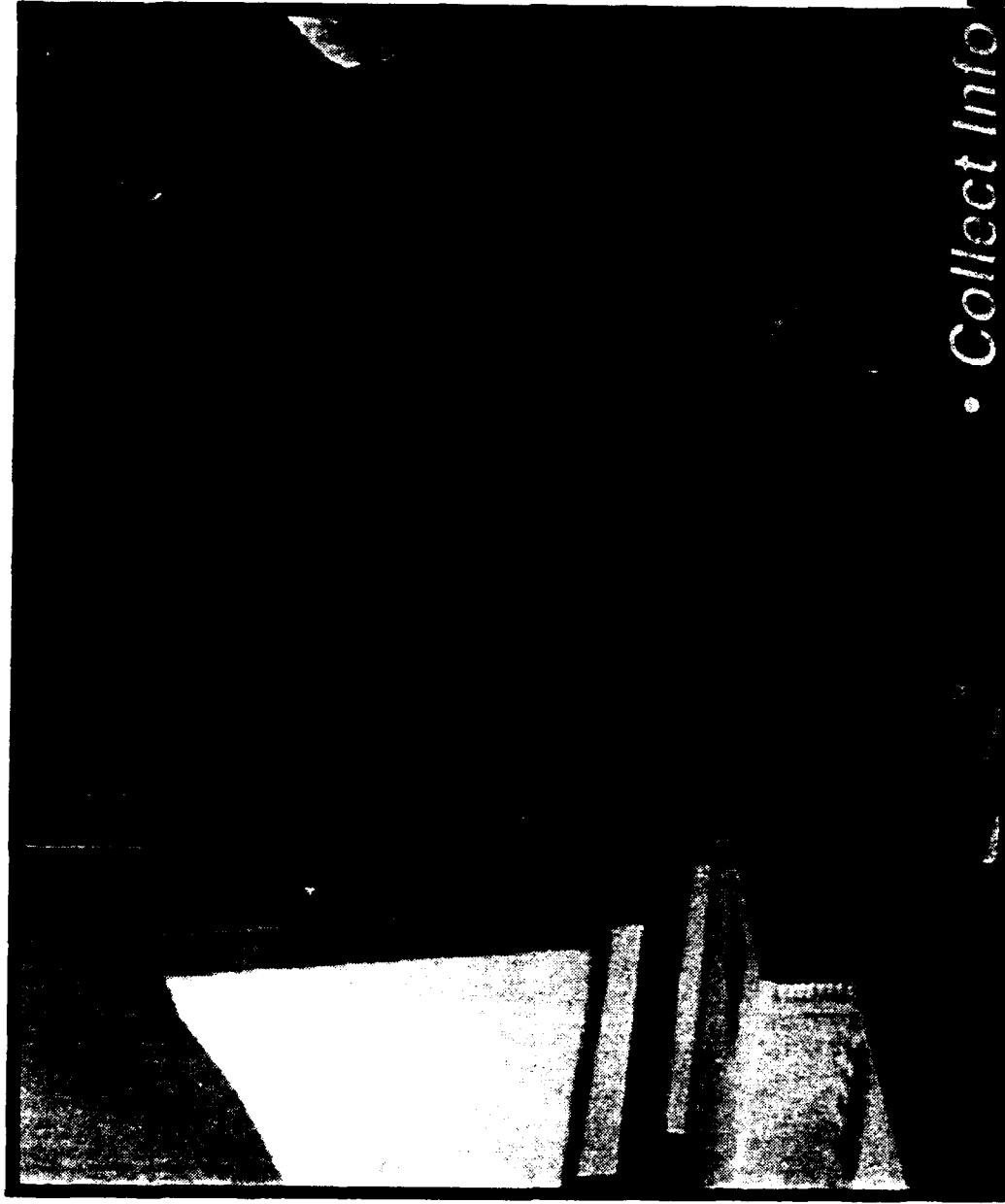
- **CSERIAC**  
**Crew System Ergonomics  
Information Analysis Center**
- **DACS**  
**Data and Analysis Center for  
Software**
- **MTIAC**  
**Manufacturing Technology  
Information Analysis Center**
- **NTIAC**  
**Nondestructive Testing  
Information Analysis Center**
- **SURVIAC**  
**Survivability/Vulnerability  
Information Analysis Center**



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## ***Worldwide Information***



**• Collect Information on  
a Worldwide Basis**



## **IAC Functions - User Perspective**

- **Answer Questions**
  - **Referrals**
  - **Bibliographic Inquiries**
  - **Techniques and Methods**
  - **Data Analysis**
  - **Current Awareness**
- **Provide Advice**
  - **Technical Advisory Services**
  - **Technical Transfer**
  - **Studies and Analyses**
  - **Symposia, Conferences, Workshops**



## ***IAC Operations***

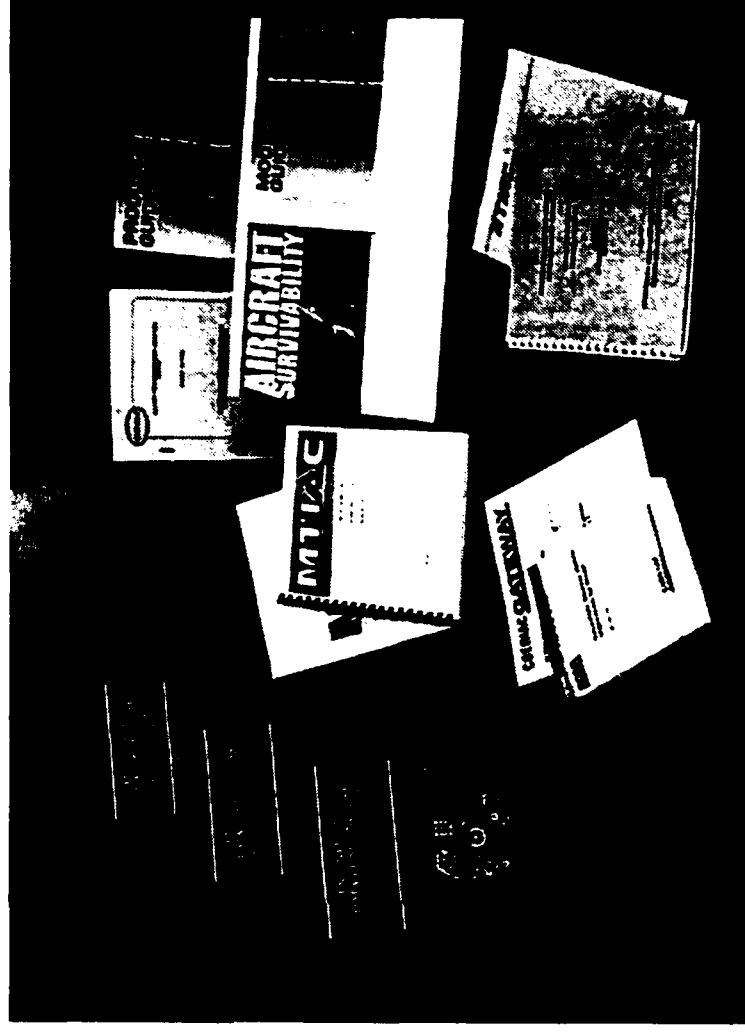
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- **Information Collection**
  - **Discipline and/or Mission Focus**
  - **Domestic and International**
  - **All Media**
  - **Classified/Unclassified**
  - **Limited/Unlimited Distribution**
- **Information Storage and Retrieval**
- **Information Synthesis and Analysis**
  - **Analytical Tools and Techniques**
  - **Studies and Analyses**
- **Information Dissemination**



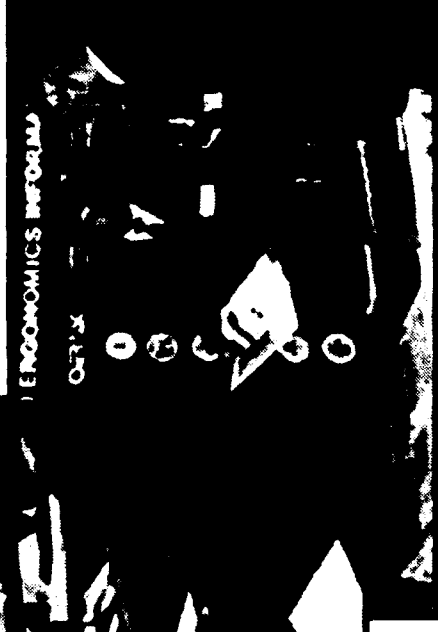
## ***IAC Information Products and Services***

- **IAC Products**
  - **Reference Tools (Handbooks, Data Books, etc.)**
  - **Models and Simulations**
  - **Standards and Specifications**
  - **Studies and Analyses**



## ***IAC Information Products and Services***

- **Technical Information Services**
- **Referrals**
- **Bibliographic and Technical Inquiries**
- **Advice**
- **Program and Project Support (per CAAS Directive)**



## Subject-Matter Coverage



### Three Taxonomies



- Military Forces and Mission Areas
- Key Technologies
- Science and Technology Thrusts





# DoD Missions and Functional Areas

DoD Missions and Functional Areas Selected IACs	Nuclear Forces	Ground Forces	Naval Forces	Tactical Air Forces	SOF	Intelligence	Communications	Logistics	Training	Installations
<b>CBIAC</b>		✓	✓	✓	✓	✓	✓	✓	✓	✓
<b>CIAC</b>		✓	✓	✓	✓	✓	✓			
<b>CSERIAC</b>		✓	✓	✓					✓	
<b>GACIAC</b>	✓	✓	✓	✓		✓			✓	
<b>HTMIAC</b>	✓	✓	✓	✓						
<b>MIAC</b>	✓	✓	✓	✓						
<b>MMCIAC</b>	✓	✓	✓	✓	✓			✓		
<b>MTIAC</b>					✓	✓		✓	✓	✓
<b>NTIAC</b>		✓	✓	✓	✓	✓		✓	✓	
<b>SURVIAC</b>		✓	✓	✓	✓	✓	✓		✓	
<b>TWSTIAC</b>		✓	✓	✓	✓	✓	✓	✓	✓	✓



## IACs and Key Technologies

Technology Interest of Potential User Selected IACs	Computers	Software	Sensors	Communi- cation Networking	Electronic Devices	Environmental Effects
<b>CBIAC</b>	✓		✓		✓	✓
<b>CIAC</b>			✓		✓	
<b>CSERIAC</b>	✓			✓	✓	
<b>GACIAC</b>		✓	✓		✓	✓
<b>HTMIAC</b>		✓	✓		✓	✓
<b>MIAC</b>						✓
<b>MMCIAC</b>						✓
<b>MTIAC</b>	✓	✓	✓	✓	✓	✓
<b>NTIAC</b>	✓		✓			
<b>SURVIAC</b>		✓	✓		✓	
<b>TWSTIAC</b>	✓	✓	✓	✓	✓	✓



# IACs and Key Technologies

Technology Interest of Potential User Selected IACs	Materials and Processes	Energy Storage	Propulsion and Energy Conversion	Design Automation	Human System Interfaces
<b>CBIAC</b>					✓
<b>CIAC</b>	✓		✓		✓
<b>CSERIAC</b>				✓	✓
<b>GACIAC</b>	✓	✓	✓	✓	
<b>HTMIAC</b>	✓		✓		
<b>MIAC</b>	✓		✓		
<b>MMCIAC</b>	✓	✓	✓	✓	✓
<b>MTIAC</b>	✓				✓
<b>NTIAC</b>	✓				✓
<b>SURVIAC</b>	✓	✓	✓	✓	✓
<b>TWSTIAC</b>	✓	✓	✓	✓	✓



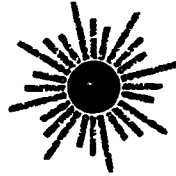
# IACs and Science and Technology Thrusts

Science and Tech Thrust of User  Selected IACs	Global Surveil- lance	Precision Strike	Air Super- iority and Defense	Sea Control/ Undersea Superiority	Advanced Land Combat	Synthetic Environ- ments	Technology for Afford- ability
<b>CBIAC</b>					✓		
<b>CIAC</b>	✓	✓	✓	✓	✓		
<b>CSERIAC</b>			✓	✓	✓	✓	✓
<b>GACIAC</b>	✓	✓	✓	✓	✓	✓	✓
<b>HTMIAC</b>		✓			✓		✓
<b>MIAC</b>			✓	✓	✓		
<b>MMCIAC</b>	✓		✓	✓	✓		✓
<b>MTIAC</b>							✓
<b>NTIAC</b>				✓	✓	✓	✓
<b>SURVIAC</b>		✓	✓	✓	✓	✓	
<b>TWSTIAC</b>		✓			✓	✓	



## **Using DoD IACs**

- **Basic Services**
  - Call, Write, Visit
  - Direct Contact with IAC
  - No or Minimal Charge
- **Extended Basic Services**
  - Direct Contact with IAC and COTR
  - Negotiated Fee for Service
- **Technical Area Tasks (TATs)**
  - Extensive Contact with IAC and COTR
  - Separate Funding and Contract Modification
  - Review and Approval by IAC Program
  - Management Office (PMO)



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## **Who To Contact**

**Defense Technical Information Center**

**Attn: DTIC-AI**

**Cameron Station**

**Alexandria, VA 22304-6145**

**Phone: (703) 274-6260 or DSN 284-6260**

**Fax: (703) 274-0980 or DSN 284-0980**

**Electronic Mail: [ffrank@dtic.dla.mil](mailto:ffrank@dtic.dla.mil)**



**IAC Benefits**

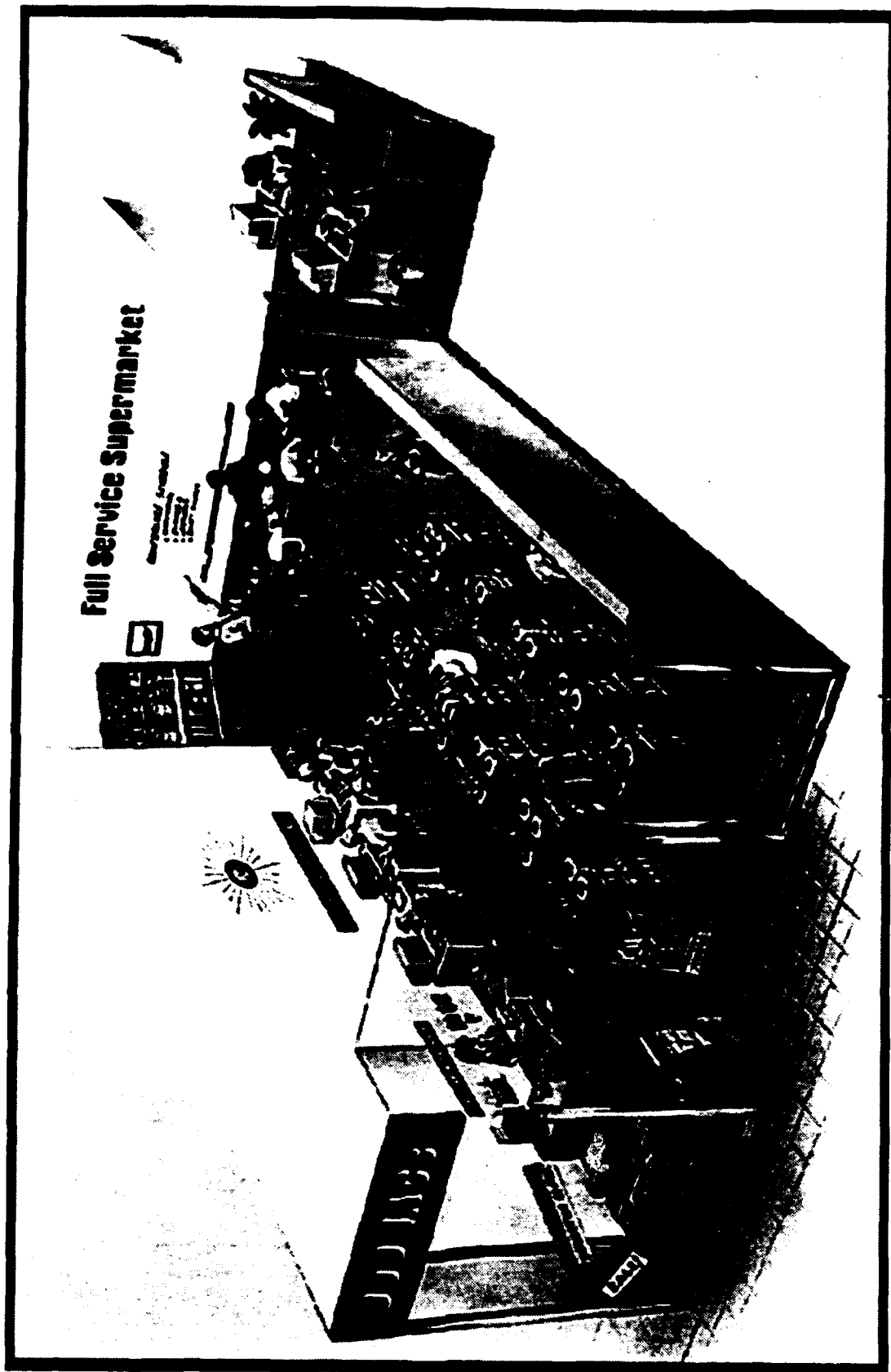
- **Quantitative Benefits**
  - **Value Engineering Analysis**
  - **Cost Avoidance**
  - **Direct Savings**
- **Qualitative Benefits**
  - **Improvements in Operational Capability**
  - **Objective Answers to Enhance User Confidence in Existing Data and Information**
  - **Standards and Specifications for Normalization of Data and Methods Used Elsewhere**



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## **DoD IAC Full-Service Supermarket**





## COMPUTERS

**MEDTAG**  
**CONCEPT EVALUATION AND PROTOTYPE**  
**DEVELOPMENT PLAN**

**Prepared by**

**Clark Fortney and James J. McNeely**  
**CBIAC**  
**Chemical Biological Information Analysis Center**  
**Battelle**  
**2113 Emmorton Park Road**  
**Edgewood, MD 21040**

**Approved for Public Release: Distribution Unlimited**

# **CONTEXT**

- **ADVANCED LAND COMBAT (S&T THRUST)**
  - **Rapid Force Deployment**
  - **Tactical Mobility**
  - **Quick Mission Accomplishment**
  - **Minimal Casualties Against Heavy Armor and Smart Weaponry**
- **NBC ENVIRONMENT LIKELY**
  - **Proliferation**
  - **Biotechnology Advances**
  - **Affects Battlefield Dynamics**
    - **Survivability**
    - **Performance Degradation**
    - **Support**

- **WHAT**
  - **Evaluate and Demonstrate the Technical Feasibility of the MEDTAG Concept**
- **WHY**
  - **Problems Associated with Present Practice - The Field Medical Card (FMC)**
    - **Rarely Implemented**
    - **Too Slow**
    - **Poor Data Quality -- Errors and Obliterations**
  - **Need for Capability in CBW Environments and Extreme Weather Conditions**
  - **Limitations Associated with Current Pilot Programs - Requirement for Interface Device -- Reader/Writer**
- **WHO**
  - **U.S. Naval Health Research Center**

## **IAC METHODOLOGY**

- **REFINE REQUIREMENTS**
- **SELECT AND EVALUATE TECHNICAL ALTERNATIVES**
- **DEVELOP PROOF-OF-CONCEPT VERSION OF MEDTAG**
- **DEMONSTRATE BASIC TECHNICAL FEASIBILITY OF MEDTAG CONCEPT**
- **DEVELOP PLAN AND OPTIONS FOR MEDTAG**
- **Miniaturization and Ruggedization**

## **RESULTS**

- **PROOF-OF-CONCEPT UNIT DESIGNED AND DEVELOPED**
- **PROOF-OF-CONCEPT DEMONSTRATED**
  - **Data Entry Time Reduced - Seconds Versus Minutes**
  - **Data Entry Accuracy Improved - Interactive Data Dictionary**
- **MINIATURIZATION AND RUGGEDIZATION PLANS DEVELOPED**

## **CONSEQUENCES**

- **DEVELOPMENT OF VIABLE APPROACH FOR IMPROVING BATTLEFIELD MEDICAL CARE**
- **POTENTIAL FOR INCREASED SURVIVABILITY OF MILITARY FORCES**

## **RELEVANCE TO OTHER USERS**

- **ALL SERVICES**
- **ALLIES**
- **CIVILIAN EMERGENCY MEDICAL SERVICES**





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# **CREW SYSTEM ERGONOMICS INFORMATION ANALYSIS CENTER (CSERIAC) PRODUCTS & SERVICES**

**Presented by**

**Donald Dreesbach  
AL/CFH/CSERIAC**

**Bldg. 248**

**2255 H Street**

**Wright-Patterson AFB, OH 45433-7022**



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## COMPUTER-AIDED SYSTEMS HUMAN ENGINEERING (CASHE)

- Definition
- Capabilities
- Justification
- CASHE Interface
- Results of CSERIAC's Efforts
- Consequences of CSERIAC's Efforts





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## **COMPUTER-AIDED SYSTEMS HUMAN ENGINEERING (CASHE): DEFINED**

- An interactive multimedia computer database for crew system design utilizing the data, figures, and tables, contained in:
  - The Engineering Data Compendium
  - Military Standard 1472 D



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## CAPABILITIES OF CASHE

- Prototyping the human factor
  - CASHE is the presentation of Human Factors information in a flexible and interactive environment:
    - » Allows the manipulation of research and design data in real-time
    - » Provides an experiential medium to simulate human performance and perception



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## JUSTIFICATION FOR THE DEVELOPMENT OF CASHE

- **Ergonomics and System Designers**
  - » Volume of material
  - » Lack of a central source of information
  - » Limited time and resources to acquire and analyze data
  - » Terminology and concepts foreign to engineering
  - » Lack of data specific to their project



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## CASHE INTERFACE

- Bookshelf
- File Management
- File Viewers
- Visualization Tools
  - Perception and Performance Prototyper
  - Data Viewer
    - » Definition
    - » Acquisition
    - » Transformation
    - » Presentation



ARMY NAVY AIR FORCE NASA FAA NATO

---

## RESULTS OF CSERIAC's EFFORTS

- CSERIAC provided the integration of many technologies and subject-matter expertise which supported:
  - » The acquisition and transformation of all graphics
  - » The development of program engines
  - » The development of test benches
  - » The development of the user manual
  - » Overall project integration resulting in a user-friendly product



## CONSEQUENCES OF CSERIAC's EFFORTS

- CSERIAC provided an environment which streamlined CASHE development
  - Task Management
    - » Contract Support
    - » Sub-contractor management
  - Contact with Subject-Matter Experts
  - Data acquisition





## **CASHE APPLICATIONS**

- **CASHE is not limited to one particular discipline or environment. It is useful to not only designers but also researchers and human factors practitioners in the DoD, Industry, and Academia.**

**DATA & ANALYSIS CENTER  
FOR SOFTWARE (DACs)**

**DACS TECHNICAL REPORTS**

**Prepared by**

**James J. Reed  
Data & Analysis Center for Software  
Kaman Sciences Corporation  
258 Genesee St., Suite 103  
Utica, NY 13502**

**Approved for Public Release: Distribution Unlimited**

## **DACS TECHNICAL REPORTS**

- **THE DACS PRODUCES AND DISTRIBUTES A VARIETY OF SOFTWARE ENGINEERING AND SOFTWARE TECHNOLOGY REPORTS OF INTEREST TO MEMBERS OF THE SOFTWARE ENGINEERING COMMUNITY.**
- **DoD Key Technologies: Computer Software / Computers**
  - o **Software and Systems Engineering**
- **DoD Science & Technology Thrust - 7**
  - o **Technology for Affordability**
- **DoD Military Missions/Functions**
  - o **Technology Transfer**

**DACS - 2**

**Prepared by: James J. Reed**

# **DACS TECHNICAL REPORT TOPIC AREAS**

- **SOFTWARE REUSABILITY**
- **DISTRIBUTED DATABASE TECHNOLOGY**
- **ARTIFICIAL NEURAL NETWORKS**
- **SOFTWARE ANALYSIS & TEST TECHNOLOGIES**
- **AN OVERVIEW OF OBJECT ORIENTED DESIGN**
- **SOFTWARE QUALITY**
- **SOFTWARE PROTOTYPING & REQUIREMENTS ENGINEERING**
- **FAST PROTOTYPING OF SOFTWARE - THE SPIRAL MODEL**
- **FORMAL METHODS**
- **NON-ADA TO ADA LANGUAGE CONVERSIONS**

**DACS - 3**

**Prepared by: James J. Reed**

# **TECHNICAL REPORT PREPARATION**

- **TOPICS SELECTED BASED ON LEVEL OF INTEREST TO MEMBERS OF THE DACS USER COMMUNITY**

- **TECHNICAL REPORT TYPES**

- **State-of-the-Art Reports**
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- **REPORT PRODUCTION**

- **DACS Staff Members**
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**DACS - 4**

**Prepared by: James J. Reed**

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**DACS - 5**

**Prepared by: James J. Reed**

# **TECHNICAL REPORT RESULTS**

- **USER CURRENCY IN THE LATEST SOFTWARE ENGINEERING TECHNOLOGIES, TOOLS, METHODS, AND MEASURES**
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**DACS - 6**

**Prepared by: James J. Reed**

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- **A SUMMARY OF DISTRIBUTED PROCESSING SYSTEMS**
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- **ADVANCED ARCHITECTURES FOR DISTRIBUTED SYSTEMS**
- **SOFTWARE PROCESS METRICS AND MEASURES**

**DACS - 7**

**Prepared by: James J. Reed**



**DATA & ANALYSIS CENTER  
FOR SOFTWARE (DACs)**

**OPEN ARCHITECTURE SYSTEMS FOR  
PROCESS AUTOMATION (OASYS)**

**Prepared by**

**James J. Reed  
Data & Analysis Center for Software  
Kaman Sciences Corporation  
258 Genesee St., Suite 103  
Utica, NY 13502**

**Approved for Public Release: Distribution Unlimited**

# **OPEN ARCHITECTURE SYSTEMS FOR PROCESS AUTOMATION (OASYS) TOOLSET**

- **THE OASYS TOOLSET FOR PROCESS AUTOMATION IS A  
SUITE OF SOFTWARE TOOLS USED FOR THE RAPID  
PROTOTYPING AND LOW-COST MAINTENANCE OF  
WORKFLOW PROCESS SYSTEMS.**
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  - o **Software for Parallel & Heterogeneous Distributed Systems**
- **DoD Science & Technology Thrust - 7**
  - o **Technology for Affordability**
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**DACS - 2**

**Prepared by: James J. Reed**

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- **OPEN SYSTEM ENVIRONMENT OPERATIONS**
- **ROUTING, PROCESSING & TRACKING OF FORMS & IMAGES**
- **REPLACEMENT FOR HIGH MAINTENANCE SYSTEMS**
  
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**PICCATINNY ARSENAL, NJ**  
**AND**  
**USAF ROME LABORATORY**  
**Griffiss AFB, NY 13441**

**DACS - 3**

**Prepared by: James J. Reed**

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- **OASYS TOOLSET METHODOLOGY EMPLOYED**

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- **Object Oriented Design**
- **Client/Server Architecture**

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- **Open Systems Environment**
- **Requirements Engineering**
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- **User Training**
- **User Maintained**

**Prepared by: James J. Reed**

**DACS - 4**

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- **PROBLEMS & RESOLUTIONS**
- **PAPERLESS SYSTEM**

**DACS - 5**

**Prepared by: James J. Reed**

# **OASYS TOOLSET RESULTS IN TDP TRACKER**

- **TDP TRACKER GOALS**
  - **Link Multiple Users in Distributed System**
  - **Reduce TDP Processing Time From Over 190 to Less Than 60 Days**
  - **Reduce Cost/Improve Quality**
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- **TDP TRACKER RESULTS**
  - **> 700 Users at Dover, NJ, Rock Island, IL, and Aberdeen, MD**
  - **Processing Time < 28 Days**
  - **Cost Savings of > \$400,000.00 Per Day**
  - **All Electronic System**
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**Prepared by: James J. Reed**

**DACS - 6**

## **ADDITIONAL APPLICATIONS**

- **USA WATERVLIET ARSENAL - ACQUISITION SYSTEM**
- **DTIC - IAC PROGRAM TECHNICAL AREA TASK TRACKER**
- **USA LIFE CYCLE SOFTWARE ENGINEERING CENTER  
UPGRADE 10 YEAR OLD ACQUISITION SYSTEM**
- **KAMAN AND OTHER CORPORATE CUSTOMERS IN  
MANUFACTURING / PRODUCTION ENVIRONMENTS**
- **ANY GOVERNMENT OR COMMERCIAL PROCESS  
AUTOMATION SYSTEM REQUIRING DOCUMENT/DATA  
MANAGEMENT**

**DACS - 7**

**Prepared by: James J. Reed**

# **TWSTIAC SUPPORT TO DEVELOPMENT OF A NETWORKED CD-ROM DATABASE**

**Prepared by**

**James Dorsey  
Defense Technical Information Center**

**Howard McQueen  
CD Consultants, Inc.  
Baltimore, MD 21210**

**and**

**Larry W. Williams, Ph.D.  
Program Manager, TWSTIAC  
Battelle Memorial Institute  
505 King Avenue  
Columbus, OH 43201-2693**

**Approved for Public Release: Distribution Unlimited**

(The final report for this study is Limited Distribution and/or Classified.)



# CONTEXT

- S&T THRUST 7: TECHNOLOGY FOR AFFORDABILITY
- DoD KEY TECHNOLOGIES 1, 2, AND 4: COMPUTERS, SOFTWARE, AND COMMUNICATIONS NETWORKING
  - "... to advance the state of the art and state of the practice of data, information, and signal processing for military missions and systems."
  - "... the timely generation, maintenance, and enhancement of affordable and reliable applications software... For distributed systems..."
  - "... shared communications media and common hardware and applications software to enable the timely, reliable, and secure production and worldwide dissemination of information..."

Prepared by: J. Dorsey-DTIC/  
H. McQueen-CD Consultants, Inc./  
L. W. Williams-TWSTIAC

TWSTIAC-2

Dorsey.vu

# **TWSTIAC PRODUCT**

- **DTIC REQUIRES A SYSTEM ARCHITECTURE FOR A CD-ROM-BASED INFORMATION SYSTEM**
  - **For storage, search, and retrieval**
  - **Of full text publications, indexes, and graphics**
  - **Compatible with the existing DTIC LAN**
  - **Providing simultaneous, multi-user multi-platform access**
  - **To DTIC offices and staff of the Office of the Undersecretary of Defense for Acquisitions and Technology**

Prepared by: J. Dorsey-DTIC/  
H. McQueen-CD Consultants, Inc./  
L. W. Williams-TWSTIAC

TWSTIAC-3

Dorsey.vu

# **TWSTIAC METHODOLOGY**

- **REVIEW TECHNICAL LITERATURE ON CD-ROM DATABASES**
- **DO A SYSTEMS ANALYSIS OF EXISTING DTIC NETWORK**
- **PROVIDE OPTIONS FOR IMPLEMENTING CD-ROM VIA THE DTIC NETWORK**
- **SPECIFY METHODS FOR SUPPORTING ACCESS TO THE CD-ROM APPLICATIONS BY DIVERSE OPERATING SYSTEMS**
- **PROVIDE ALTERNATIVE SYSTEM CONFIGURATIONS, IMPLEMENTATION PLAN, AND EQUIPMENT LIST**
- **PERFORM SHAKEDOWN OPERATION OF THE INSTALLED SYSTEM**

Prepared by: J. Dorsey-DTIC/  
H. McQueen-CD Consultants, Inc./  
L. W. Williams-TWSTIAC

TWSTIAC-4

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# **DATA ANALYSIS**

- **CHARACTERIZED DTIC LAN USER ENVIRONMENT**
- **IDENTIFIED CONSIDERATIONS AND OPTIONS FOR IMPLEMENTING ACCESS BY DIVERSE OPERATING SYSTEMS**
- **RECOMMENDED SYSTEM ARCHITECTURES**
- **RECOMMENDED EQUIPMENT TO SUPPORT THE SOLUTION**

Prepared by: J. Dorsey-DTIC/  
H. McQueen-CD Consultants, Inc./  
L. W. Williams-TWSTIAC

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# CONSEQUENCES

- **SIGNIFICANT COST SAVINGS ARE PROJECTED**
  - **Electronic data transfer will replace hardcopy printing/transporting**
  - **Reduced number of personnel interventions**
  - **Real-time system response to requirer of information/data**
  - **Save 40-56 minutes of staff time per search--system will pay for itself after 2,666 searches**

Prepared by: J. Dorsey-DTIC/  
H. McQueen-CD Consultants, Inc./  
L. W. Williams-TWSTIAC

TWSTIAC-6

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## **CONSEQUENCES (Continued)**

- **OTHER BENEFITS INCLUDE**
  - **Synergy with rapidly growing commerical CD-ROM information industry**
  - **Integrated searching tool will provide single-search access to multiple sources**
  - **Will allow DTIC to more rapidly bring on-line new information received and new information sources**
- **ANTICIPATED CHANGES IN DTIC OPERATIONS**
  - **Greater flexibility in meeting subscribers' needs**
  - **Greater responsiveness in meeting DoD requirements (e.g., in changing Military Standards)**

Prepared by: J. Dorsey-DTIC/  
H. McQueen-CD Consultants, Inc./  
L. W. Williams-TWSTIAC

TWSTIAC-7

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## **RELEVANCE TO OTHER USERS**

**THIS SOLUTION WILL BE ADVANTAGEOUS TO OTHERS WHO NEED  
TO TRANSMIT CD-ROM BASED IMAGES OVER LAN'S OR T-1 LINES  
ALREADY SATURATED WITH HIGHER PRIORITY TRAFFIC**

Prepared by: J. Dorsey-DTIC/  
H. McQueen-CD Consultants, Inc./  
L. W. Williams-TWSTIAC

TWSTIAC-8

Dorsey, WU

# **ISSUES FACING NETWORK IMPLEMENTATION**

- **DOS SEARCH/RETRIEVAL SOFTWARE REQUIRES ~490K RAM IN CLIENT (PENTAGON WORKSTATIONS MAY BE A PROBLEM)**
- **NETBIOS (LAN MAN AND PATHWORKS) IS THE ONLY COMMON NETWORKING PROTOCOL**
- **SUGGESTED CONFIGURATION:**
  - **Magnetic indexes at both sites**
  - **Shared image server**
  - **87 + CD-ROM image discs**
- **WHAT'S MISSING FROM THE SOLUTION**
  - **Windows search/retrieval interface**
  - **CD-ROM networking software which can translate between 87 consecutive image discs**

Prepared by: J. Dorsey-DTIC/  
H. McQueen-CD Consultants, Inc./  
L. W. Williams-TWSTIAC

TWSTIAC-9

Dorsey.vu





# **COMPUTERS & SOFTWARE COMMUNICATIONS NETWORKING**

**Prepared by**

**Ernest Smart**

**Deputy Program Manager, TWSTIAC  
Institute for Simulation & Training**

**University of Central Florida**

**3280 Progress Drive**

**Orlando, FL 32826**

**Approved for Public Release: Distribution Unlimited**

# **CONTEXT**

- **COMPUTERS & SOFTWARE**
  - High performance computing systems providing orders of magnitude improvements in Modeling & Simulation
- **COMMUNICATIONS NETWORKING**
  - The timely, reliable, and secure production and worldwide dissemination of information using shared communications media and common hardware and application software, organized/managed through established standards and protocols in support of Training, Military Operations, and Research, Development, & Acquisition (RDA)

## **TWSTIAC PRODUCTS**

- **INFORMATION ON ADVANCED APPLICATIONS OF DISTRIBUTED SYSTEMS AND NETWORKING TECHNOLOGY**
  - Catalog of program applications
  - DIS Test Bed
  - IEEE DIS Standards & Protocols
- **DIS EDUCATION / WORKSHOPS**
  - Standards Workshops
  - User Application Workshops
  - Computer Generated Forces (CGF) Workshops

## **METHODOLOGY**

- **VARIETY OF METHODS USED, INCLUDING ...**
  - Survey of key Users / Developers
  - Analysis based on expert panel, peer review, & technical assessments
  - Research on entity representation & alternative networking
- **APPROACH: TRADITIONAL MIXED WITH NEW IDEAS**
  - Applications of DELPHI technique to establish priorities
  - Electronic "Town Meetings" focused on special interest groups
  - Expert seminars organized in conjunction with national conferences; e.g., I/ITSEC, AUSA
  - User workshops geared to change the way Users think and introduce new paradigms for leveraging efforts

## **SUMMARY OF DATA**

- **DATA COLLECTION CATEGORIES**
  - Expert Points of Contact
  - “LESSONS LEARNED” on research findings
  - Key research initiatives sorted by requirements
  - Standards and protocols for networked applications
  - Service and DOD regulatory requirements
  - Key Industry members in the communications field
- **INTERESTING CHARACTERISTICS**
  - Inconsistency in data elements across Users
  - “FEAST OR FAMINE” population of data across areas
  - Lack of configuration control on data
  - Breadth & diversity of Users
  - Volume & quantity of data

## **RESULTS OF DATA ANALYSIS**

- **FINDINGS**

- Condition of networking is of such diversity that linkages can only be accomplished via standard protocols
- Methods of sharing networking solutions are not widely publicized
- Interservice solutions are rare

- **SUMMARY OF TECHNICAL RECOMMENDATIONS**

- Policy on standards in applications must be developed to recognize variety of previous applications
- Standards of data, database design, and horizontal integration are needed to meet the operational needs of Users

# SOFTWARE



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# **CREW SYSTEM ERGONOMICS INFORMATION ANALYSIS CENTER (CSERIAC) PRODUCTS & SERVICES**

**Presented by**

**Donald Dreesbach  
AL/CFH/CSERIAC**

**Bldg. 248**

**2255 H Street**

**Wright-Patterson AFB, OH 45433-7022**





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## **ADVANCED HUMAN SYSTEM INTERFACE DESIGN IN CONTROL ROOMS**

- **Task Overview & Project History**
- **Shortcomings of Scientific and Technical Information**
- **Subject Matter Reviewed**
- **CSERIAC's Review and Analysis Services**
- **Results of CSERIAC's Efforts**
- **Consequences of CSERIAC's Efforts**
- **Applications**





## **PROJECT OVERVIEW AND HISTORY**

- **CSERIAC and the Nuclear Regulatory Commission**
  - » Human Systems Interface Design Review Guideline (NUREG/CR-5908)
- **Project History**
  - » Document review process



## **SHORTCOMINGS OF SCIENTIFIC AND TECHNICAL INFORMATION**

- **Shortcomings of Scientific and Technical Information,  
Control Rooms Revisited:**
  - » **Changing technology**
  - » **Research gaps**
  - » **Advances in human factors research**



## **SUBJECT MATTER REVIEWED BY CSERIAC**

- **Human factors and control room design**
  - » **Display and Control Technologies**
  - » **Automation, Intelligent Aids, and Human Error**
  - » **Nuclear Power Plant Control Room Integration**



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## CSERIAC REVIEW & ANALYSIS SERVICES

- Purpose
- Procedure
- Content
- Synthesis



## **RESULTS OF CSERIAC's EFFORTS**

- **Reviews & Analyses Final Reports:**
  - » **Display and Control Technologies**
  - » **Automation, Intelligent Aids, and Human Error**
  - » **Nuclear Power Plant Control Room Integration**



## CONSEQUENCES OF CSERIAC's EFFORTS

- **Project Evaluation**
- **Further Study**
- **Update:**
  - » Advanced Human Systems Interface Design Review Guideline
  - » The design of future control facilities



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## APPLICATIONS

- **Benefits to the design of control facilities:**
  - » Extensive review of display control technologies
  - » Expanding upon research and applications of human factors in automation
  - » Expanding upon research and applications of artificial intelligence
  - » Expanding upon research in the area of human error
  - » Expanding upon research in the area of system integration





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## **HUMAN FACTORS IN THE DESIGN OF SYNTHETIC ENVIRONMENTS**

- Task Overview
- Project Scope
- Subject Matter Addressed
- CSERIAC Search & Summary Services
- Results of CSERIAC's Efforts
- Consequences of CSERIAC's Efforts
- Applications



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## **HUMAN FACTORS IN THE DESIGN OF SYNTHETIC ENVIRONMENTS**

- **Definition**
- **Benefits**
- **Components**
- **Goals**
- **Results of CSERIAC's Efforts**
- **Consequences of CSERIAC's Efforts**
- **Applications**



## **HUMAN FACTORS IN THE DESIGN OF SYNTHETIC ENVIRONMENTS: TASK OVERVIEW**

- **CSERIAC support of the Small Business Innovative Research Program**
  - » Intelligent Information Presentation for Helmet Mounted Displays in Synthetic Environments
  - » Force Tactile Feedback for Virtual Reality Environments
  - » Interaction with 3-D "Virtual" Environments



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## STATE-OF-THE-ART HUMAN FACTORS TECHNICAL INFORMATION: PROJECT SCOPE

- Exploration of literature to support research for innovative concepts to solve defense-related scientific or engineering problems.
  - » Explore the presentation of tactical information
  - » Review how humans use tactile feedback in manipulating controls and displays
  - » Investigate how humans interact with 3-D virtual environments



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## **SUPPORTING INNOVATIVE RESEARCH: SUBJECT MATTER ADDRESSED**

- **CSERIAC identified:**
  - Research on the presentation of information for Helmet Mounted Displays
    - » Pilot information load
    - » Information usage
    - » Hardware constraints
  - Literature on force tactile feedback
  - Information for the creation of natural and realistic environments.



## CSERIAC SEARCH & SUMMARY SERVICES

- Definition
- Procedure
- Purpose
- Scope



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## RESULTS OF CSERIAC's EFFORTS

- Intelligent Information Presentation for Helmet Mounted Displays in Synthetic Environments
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## CONSEQUENCES OF CSERIAC's EFFORTS

- CSERIAC provided a firm basis so small businesses could meet the research needs of the Department of Defense.



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## APPLICATIONS

- There are few limitations to the scope of CSERIAC's Research. Although the information is intended for use in aviation settings, the results can be applied to most research and development for synthetic environments.

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**DACS TECHNICAL REPORTS**

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**DACS - 2**

**Prepared by: James J. Reed**

# **DACS TECHNICAL REPORT TOPIC AREAS**

- **SOFTWARE REUSABILITY**
- **DISTRIBUTED DATABASE TECHNOLOGY**
- **ARTIFICIAL NEURAL NETWORKS**
- **SOFTWARE ANALYSIS & TEST TECHNOLOGIES**
- **AN OVERVIEW OF OBJECT ORIENTED DESIGN**
- **SOFTWARE QUALITY**
- **SOFTWARE PROTOTYPING & REQUIREMENTS ENGINEERING**
- **FAST PROTOTYPING OF SOFTWARE - THE SPIRAL MODEL**
- **FORMAL METHODS**
- **NON-ADA TO ADA LANGUAGE CONVERSIONS**

**DACS - 3**

**Prepared by: James J. Reed**

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**DACS - 4**

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**DACS - 6**

**Prepared by: James J. Reed**



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**DACS - 7**

**Prepared by: James J. Reed**

**DATA & ANALYSIS CENTER  
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**OPEN ARCHITECTURE SYSTEMS FOR  
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**DACS - 2**

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**Griffiss AFB, NY 13441**

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**DACS - 4**

**Prepared by: James J. Reed**

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**DACS - 5**

**Prepared by: James J. Reed**

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**DACS - 6**

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- **DTIC - IAC PROGRAM TECHNICAL AREA TASK TRACKER**
- **USA LIFE CYCLE SOFTWARE ENGINEERING CENTER  
UPGRADE 10 YEAR OLD ACQUISITION SYSTEM**
- **KAMAN AND OTHER CORPORATE CUSTOMERS IN  
MANUFACTURING / PRODUCTION ENVIRONMENTS**
- **ANY GOVERNMENT OR COMMERCIAL PROCESS  
AUTOMATION SYSTEM REQUIRING DOCUMENT/DATA  
MANAGEMENT**

**DACS - 7**

**Prepared by: James J. Reed**



## **SENSORS**

# **BIO TECHNOLOGY: A SURVEY OF SEVEN TECHNOLOGIES TO IDENTIFY CLOSTRIDIUM BOTULINUM AND BACILLUS ANTHRACIS**

**Prepared by**

**Dr. Salvatore Bosco, Dr. Leo Laughlin, Milton Miles and James McNeely  
CBIAC  
Chemical Biological Information Analysis Center  
Battelle  
2113 Emmorton Park Road  
Edgewood, MD 21040**

**Approved for Public Release: Distribution Unlimited**

# **CONTEXT**

- **BIOLOGICAL WARFARE CONVENTION TECHNICAL DISCUSSIONS**
- **IDENTIFY TECHNICAL ISSUES ASSOCIATED WITH DEVELOPMENT OF VERIFICATION INITIATIVES**

**Prepared by: Salvatore Bosco, et al**

**CBIAC - 2**



## **BIO TECHNOLOGY TASK**

- **WHY**
  - **Technical Exchanges**
    - International Assertions on BWC Verifiability
    - Claims of Equipment Capabilities
    - Provide Common Denominator for Comparison of Technical Specifications
    - Need to Define Technical Terminology
    - Capture Current Information on Rapid-Paced Technological Advances
    - Provide Technical Information to Negotiators who have Little Technical Background
    - Technical and Policy Experts use same "Sheet of Music"
    - Need to Address Real-World Problems
      - False Positive (vs False Negatives)
      - Masking Issues/Interferences
- **WHO**
  - Office of the Secretary of Defense (OSD/ISP/MN)
- **WHAT**
  - Technical Review of Leading Edge Technologies for Identification of Botulinum and Anthrax

## **IAC METHODOLOGY**

- **SCOPE TO WORKABLE SET OF TECHNOLOGIES FOR PROOF OF CONCEPT**
- **WORLD-WIDE SEARCH FOR RELEVANT LITERATURE**
- **CULL FOR QUANTITATIVE INFORMATION ON SPECIES IDENTIFICATION**
- **MATRIX TECHNOLOGIES VS AGENTS**
- **CREATE ROLL-UP SECTIONS WITH INCREASING DEGREES OF TECHNICAL DETAIL**
- **THOROUGHLY REFERENCED**
- **EXPERT REVIEW AND EVALUATION OF TECHNICAL/MEDICAL LITERATURE**

## **SUMMARY OF DATA**

- **OVERVIEW OF CUTTING-EDGE TECHNOLOGIES**
- **REVIEW OF APPLICABILITY TO SPECIFIC IDENTIFICATION**
- **EXPERIENCED SCIENTISTS FOR EVALUATION**
- **MATRIX PRESENTATION ALLOWS FOR EASY EXTENSION TO OTHER DISEASE-CAUSING ORGANISMS OF INTEREST**

## **RESULTS OF DATA ANALYSIS**

- **BW TECHNOLOGY DOCUMENT PROVIDED U.S. NEGOTIATORS WITH DATA TO EFFECTIVELY RESPOND TO PROPOSALS FOR BWC VERIFICATION REGIMES**

Prepared by: Salvatore Bosco, et al

CBIAC - 6

## **CONSEQUENCES**

- **DOCUMENT PROVIDED TO U.S. BWC TECHNICAL REPRESENTATIVES**
- **EXTRACTS OF DOCUMENT DISTRIBUTED TO INTERNATIONAL DELEGATES**



## **RELEVANCE TO OTHER USERS**

- **WORLD HEALTH ORGANIZATION**
- **INDUSTRY**
- **NATIONAL INSTITUTE OF HEALTH**
- **CENTER FOR DISEASE CONTROL**
- **ACADEMIA**

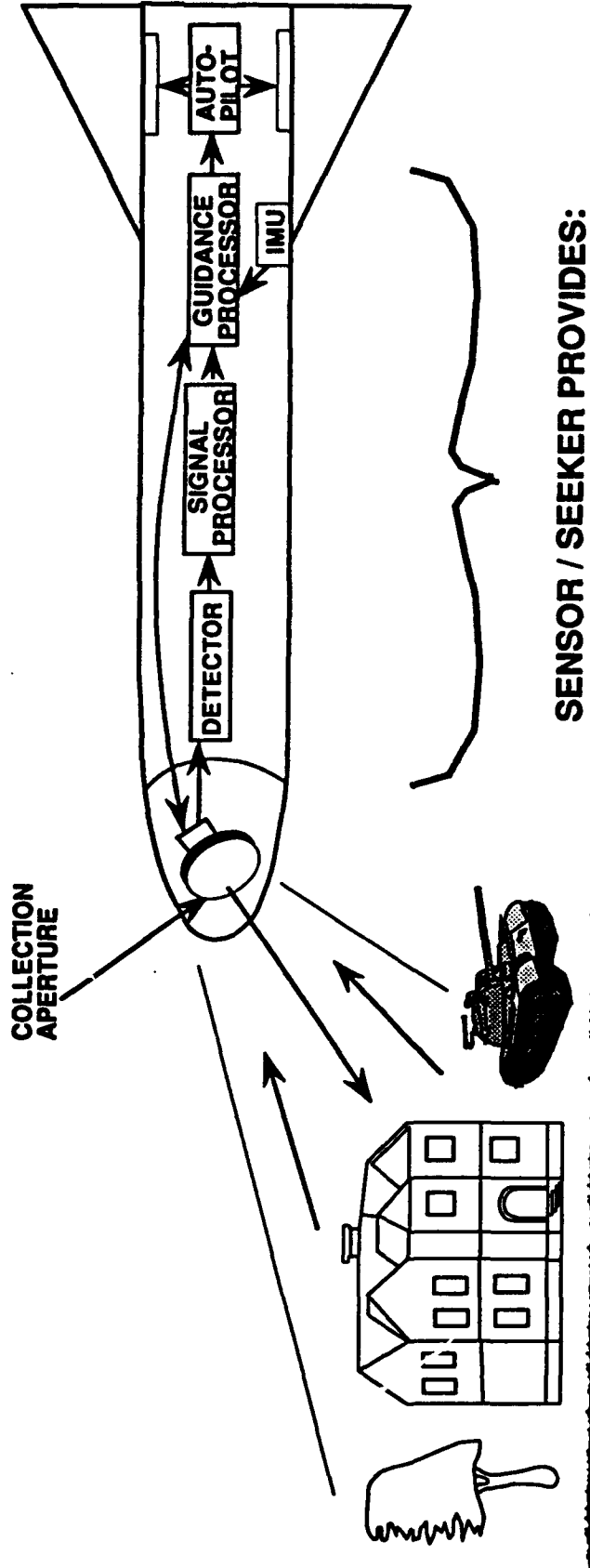


# **SENSORS AND ELECTRONIC DEVICES**

**PREPARED BY  
DR. ROBERT J. HEASTON**

**GUIDANCE AND CONTROL INFORMATION ANALYSIS CENTER  
IIT RESEARCH INSTITUTE  
10 WEST 35 STREET  
CHICAGO, IL 60616**

# SEEKERS / SENSORS CONTEXT



SENSOR FOOTPRINT  
INCLUDES  
TARGET + CLUTTER  
ATTRIBUTES

- SENSING OF TARGET ATTRIBUTE IN THE DETECTOR -- USUALLY SOME FORM OF EMITTED OR REFLECTED ENERGY.
- TARGET DETECTION DECISIONS IN THE SIGNAL PROCESSOR BASED ON TRANSDUCED SIGNALS FROM THE DETECTOR.
- RELATIVE TARGET POSITION BASED ON APERTURE LINE-OF-SIGHT AND TRACKING ALGORITHMS IN THE SIGNAL PROCESSOR SEEKER/SENSOR.



# REPRESENTATIVE SEEKER/SENSOR ANALYSIS EFFORTS

## TITLE

MULTISPECTRAL AIR-TO-AIR SEEKER (MSAAS)  
 SMART TACTICAL AUTONOMOUS GUIDANCE (STAG)  
 LOW COST ANTI-ARMOR SUBMUNITION (LOCAAS)  
 LINE-OF-SIGHT ANTI-TANK (LOSAT) ANALYSIS  
 ADVANCED SENSOR/SEEKER DEVELOPMENT  
 BAT PREPLANNED PRODUCT IMPROVEMENT (P3I)  
 US/JAPAN DUAL MODE SEEKER COOPERATIVE EFFORT  
 BLUE VEHICLE SURVIVABILITY ASSESSMENT  
 PASSIVE DET, TRKG, & ID -- GROUND VEHICLES  
 FIELD DEMONSTRATION OF ACOUSTIC TRACKER  
 MULTI SENSOR/TARGET TRACKING

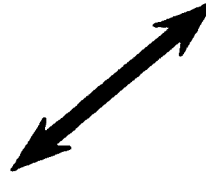


SENSOR/SEEKERS  
 IMAGING INFRARED  
 ACTIVE / PASSIVE MMW  
 ACOUSTIC  
 LASER RADAR  
 MULTIMODE / DUAL MODE  
ALGORITHMS - ATR  
 IMAGE PROCESSING  
 NEURAL NETWORKS  
 DATA FUSION  
 SIGNATURES  
 DATA COLLECTION  
 STRUCTURING & COMPILATION  
 CHICKEN LITTLE DATA  
TEST & EVAL  
 LABORATORY  
 FIELD (TOWER & CFT)  
 HWIL



## MULTIPLE CUSTOMERS

MULTIPLE SERVICES (ARMY, AIR FORCE, NAVY)  
 DTIC  
 ARPA  
 RESEARCH, DEVELOPMENT, & ENGINEERING CENTERS  
 LABORATORIES  
 PROGRAM EXECUTIVE OFFICES  
 PROGRAM MANAGEMENT OFFICES

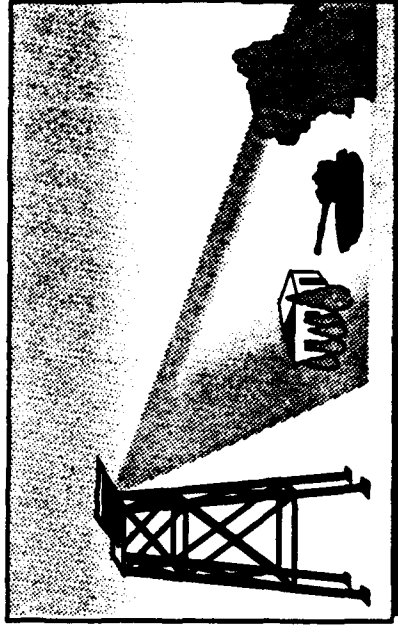


# INDEPENDENT SEEKER / SENSOR ANALYSES

## OBJECTIVE:

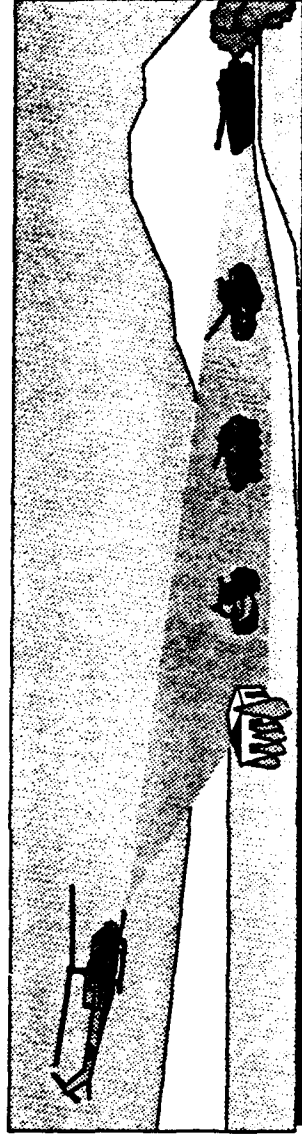
PROVIDE INDEPENDENT ANALYSIS AND ASSESSMENTS OF POTENTIAL CAPABILITIES OF VARIOUS TYPES OF SENSORS

- MMW/PASSIVE MMW
- LADAR
- INFRARED
- ACOUSTIC
- MULTI-MODE/DUAL MODE



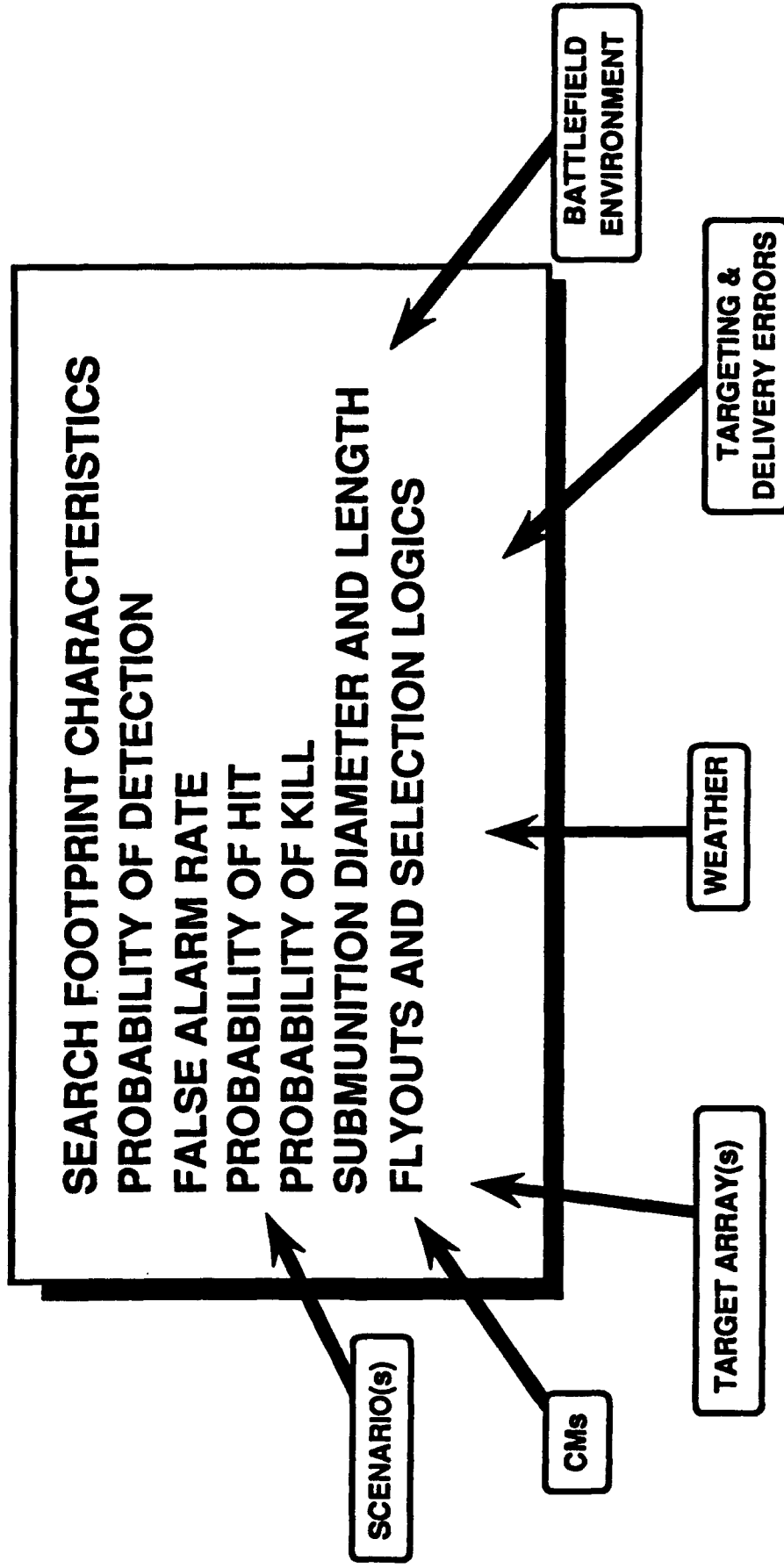
## ACTIVITIES:

- ASSIST IN TOWER AND CAPTIVE FLIGHT TEST PLANNING
- PERFORM ASSESSMENT OF SENSORS' PERFORMANCE IN FIELD TESTS (TOWER AND CAPTIVE FLIGHT TEST MANEUVERS)
- PERFORM HARDWARE AND ALGORITHM DESIGN ASSESSMENTS
- IDENTIFY STRENGTHS / WEAKNESSES OF THE SENSORS' DESIGNS



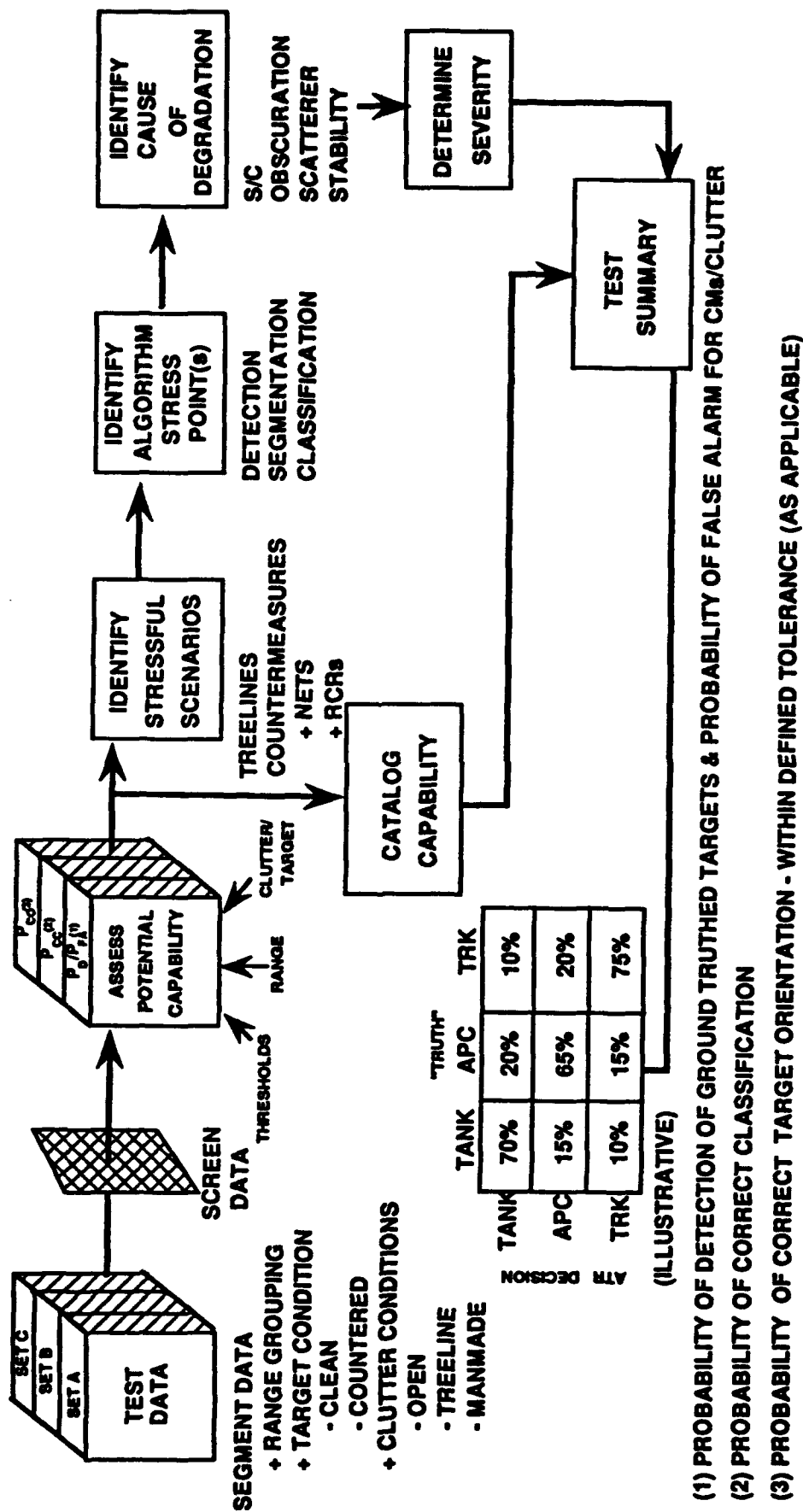
Presented By: **GACIAC**  
DR. R. J. HEASTON

# FACTORS AFFECTING SEEKER / SENSOR PERFORMANCE

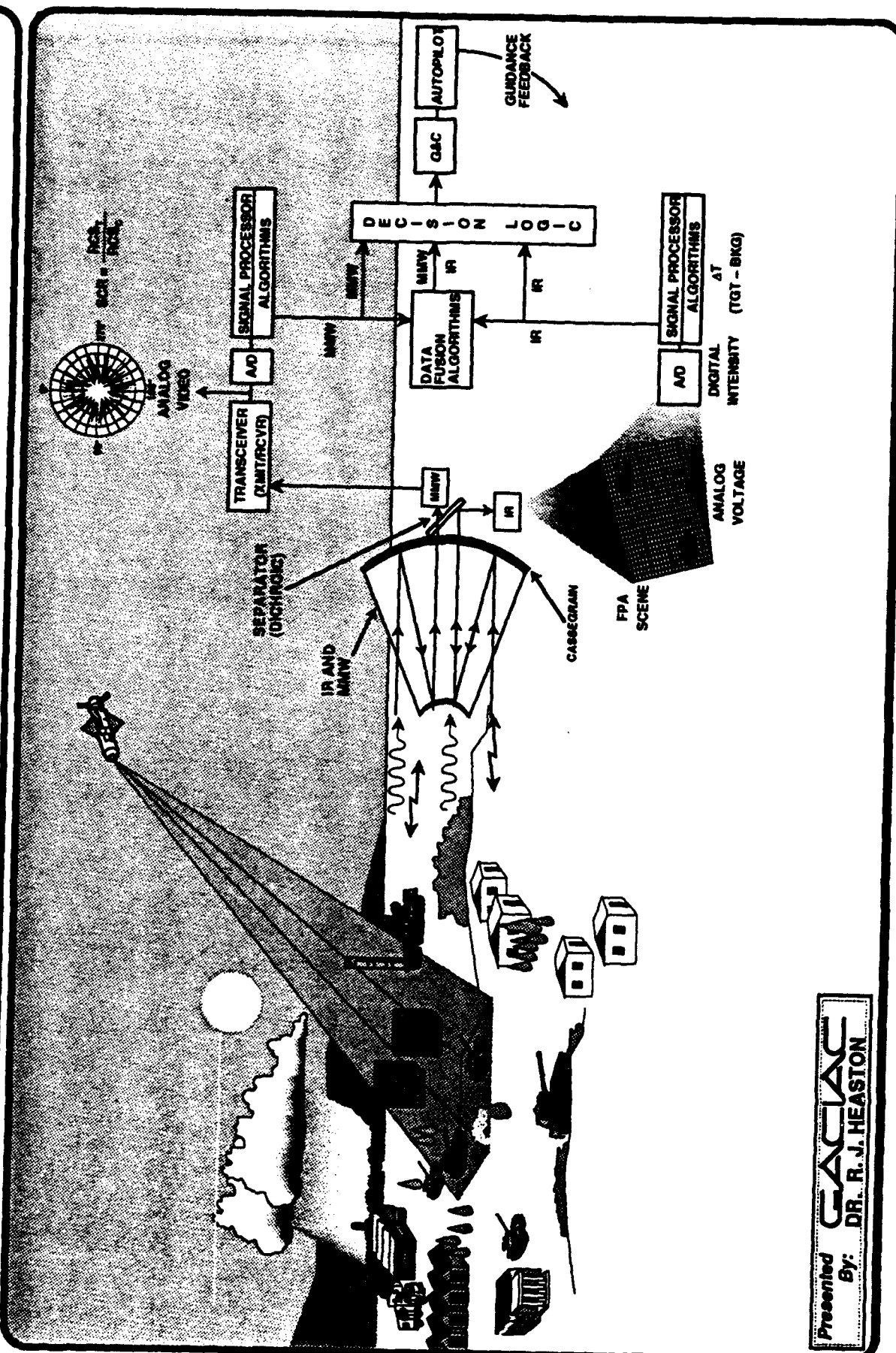


PROCESSED BY THE  
DEFENSE INFORMATION  
SYSTEMS CENTER

# CAPABILITY ASSESSMENT METHODOLOGY



# DUAL MODE REPRESENTATION

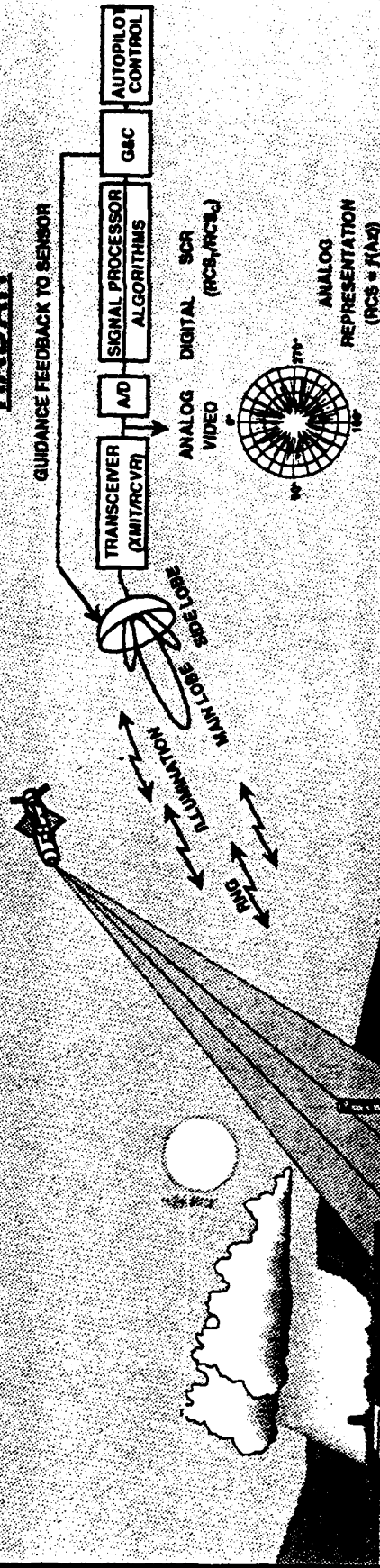


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DR. R. J. HEASTON

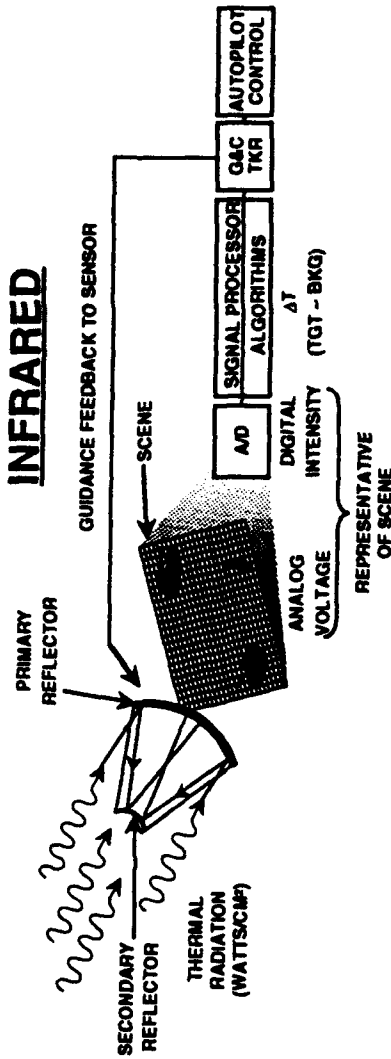


# RADAR AND INFRARED REPRESENTATION

## RADAR



## INFRARED

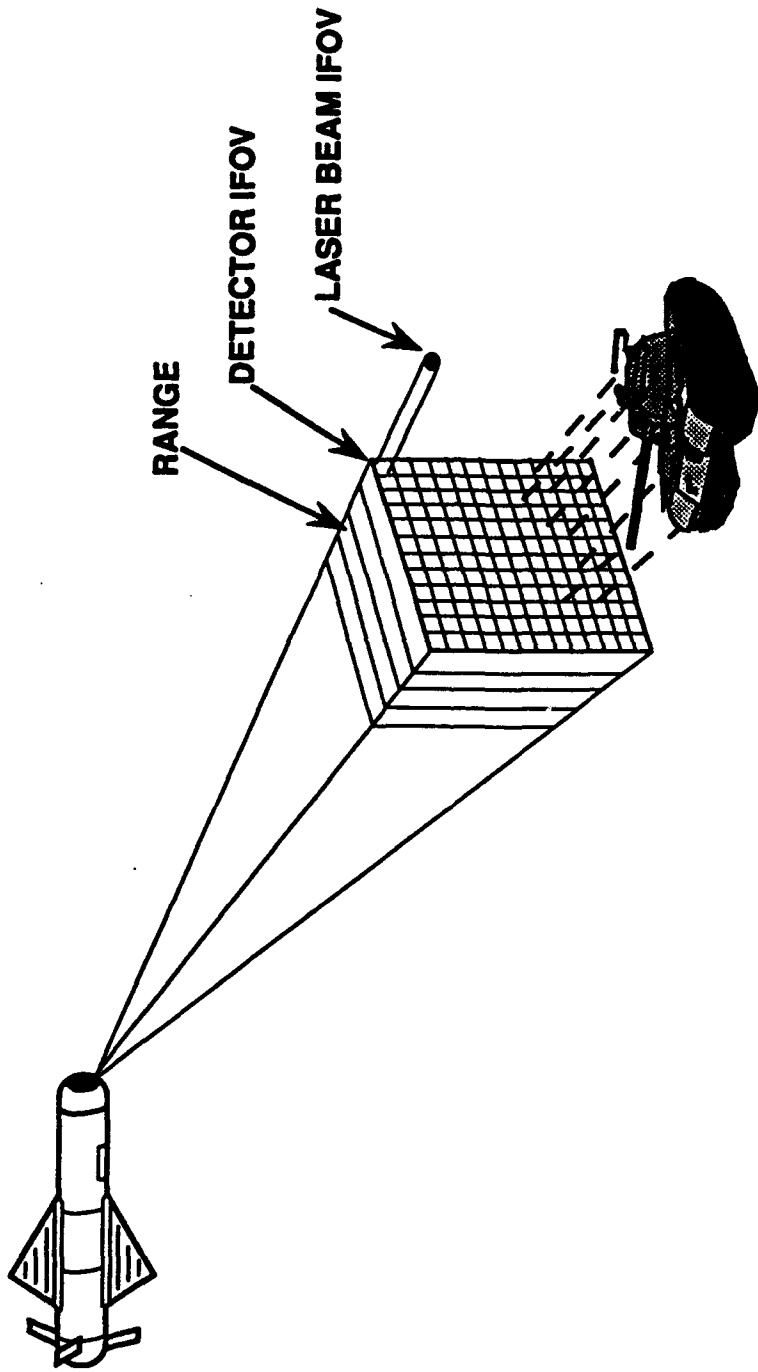


Presented By: **GACIAC**  
DR. R. J. HEASTON

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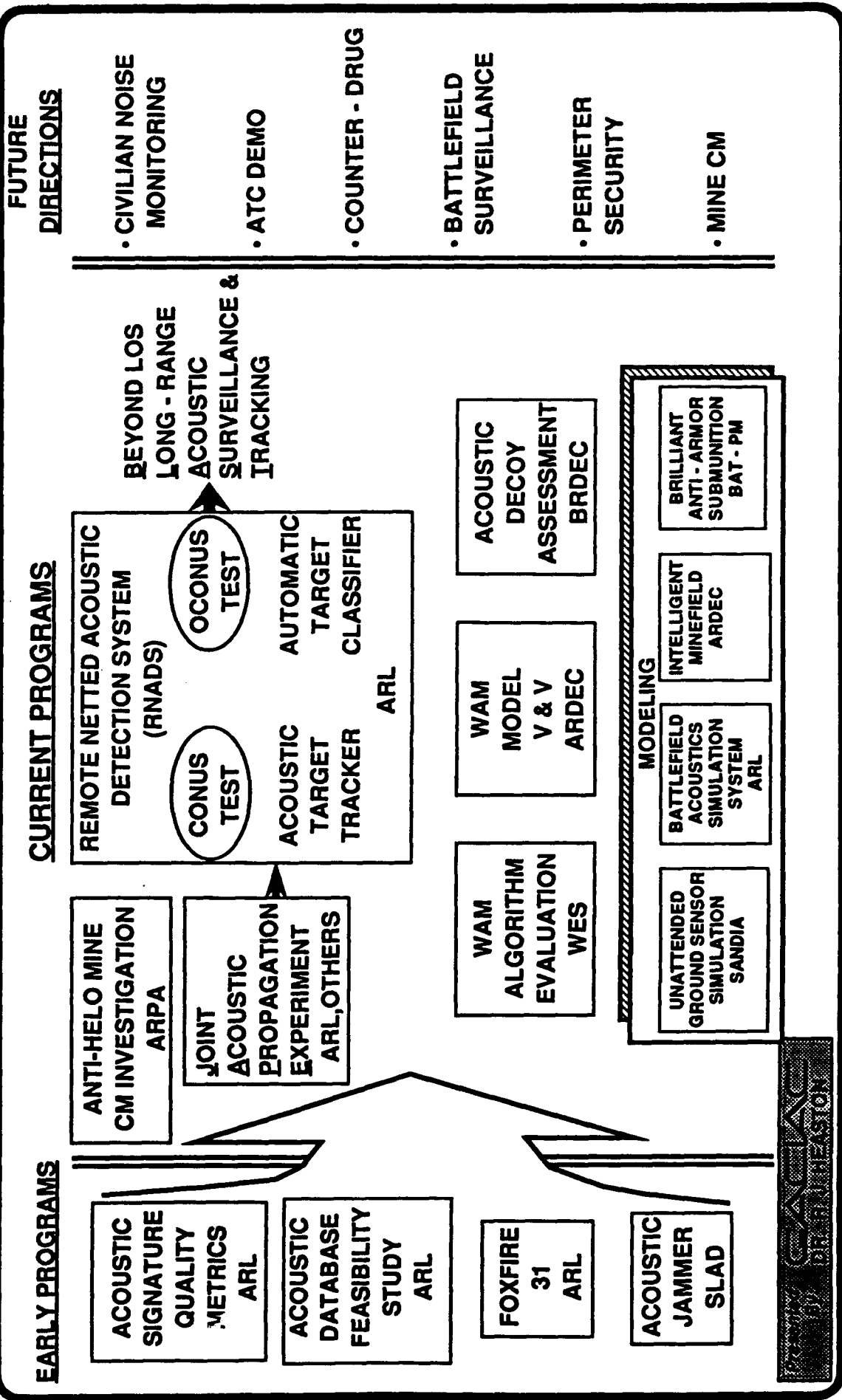
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# LADAR TARGET SIGNATURE



- LADAR SYSTEMATICALLY MEASURES RANGE TO PIXELS ON REFLECTING SURFACES
- LADAR PROVIDES HIGH RESOLUTION IN RANGE AND ANGLE (AZIMUTH AND ELEVATION)
- RESULT IS HIGH RESOLUTION 3-4 IMAGERY

# ACOUSTIC RESEARCH PROJECTS



# MULTIPLE SENSOR SUITES

- SEEKERS REQUIRE AN ARCHITECTURE TO EMPLOY THE OUTPUTS OF MORE THAN ONE SENSOR
- SEQUENTIAL OPERATION (HANDOVER) -- TAKES ADVANTAGE OF COMPLEMENTARY SENSOR CHARACTERISTICS; i.e., ACQUISITION RANGE VERSUS TRACKING ACCURACY
- SIMULTANEOUS OPERATION -- PROVIDE ADDITIONAL MARGIN OF PERFORMANCE ENHANCEMENT TO ACQUIRE AND TRACK CHALLENGING TARGETS; i.e.. LOW OBSERVABLES, HIGH VALUE AND COLD STATIONARY TARGETS

## **SUMMARY PRODUCTS / VALUE**

- **GACIAC HAS CONSIDERABLE EXPERIENCE IN STATE-OF-THE-ART SENSOR/SEEKER ANALYSIS**
  - VARIOUS SENSOR/SEEKER TECHNOLOGIES
  - SIGNAL PROCESSING TECHNIQUES/ALGORITHMS
  - TEST & EVALUATION
  - TARGET SIGNATURES
- **GACIAC PROVIDES TECHNOLOGY ASSESSMENTS, TECHNICAL REPORTS, SOTA REVIEWS, ETC.**
- **GACIAC SUPPORTS A VARIETY OF DoD CUSTOMERS AT VARIOUS LEVELS**

**DO NOT SIGNATURE**

# **SENSORS AND ELECTRONIC DEVICES: MULTISPECTRAL DETECTION**

**Presented by:**

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# **MULTISPECTRAL DETECTION: CONTEXT**

- **CAMOUFLAGED AND CONCEALED TARGETS ARE OFTEN DIFFICULT TO DETECT USING CONVENTIONAL SENSOR DUE TO LOW CONTRAST AND HIGH THERMAL NOISE**
- **REQUIREMENTS FOR RAPID SEARCH AND DETECTION HAVE INCREASED (E.G., SEARCHING FOR SCUDS DURING THE GULF WAR)**
- **BACKGROUND AND TARGETS HAVE SPECTRAL FEATURES WHICH ARE SUBJECT TO EXPLOITATION TO ENHANCE DETECTION**
- **SEVERAL MISSIONS SUPPORTED:**
  - **Tactical Sea-based Air Forces**
    - o **Reconnaissance**
    - o **Deep strike**
  - **Naval Surface**
    - o **Naval shore bombardment**
    - o **Amphibious forces support**

# **MULTISPECTRAL DETECTION TASK**

- **IMPLEMENTATION OF SENSOR KEY TECHNOLOGY (PASSIVE ELECTRO-OPTICAL SENSING)**
- **TASK FOCUS**
  - Evaluate fundamental phenomenology and mathematical basis of multispectral sensing
  - Sponsor: Naval Research Laboratory
  - Products consisted of reports, briefings, data, and analysis

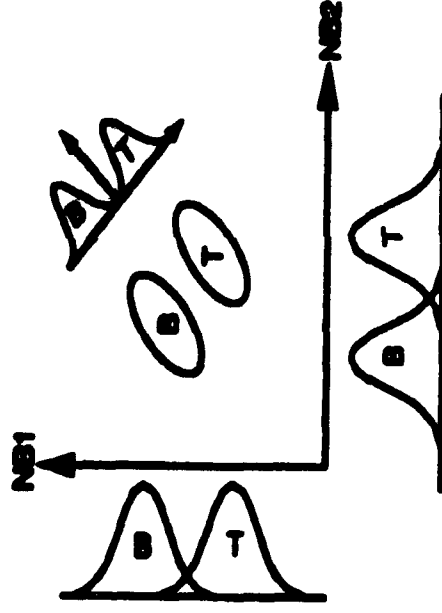
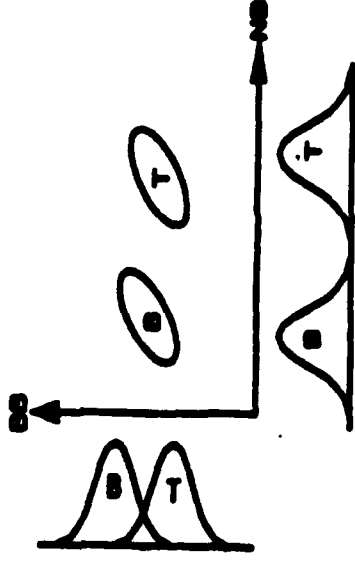


# METHODOLOGY

- **ISSUES**
  - Evaluate spectral properties
    - o Backgrounds
    - o Targets (paints)
  - Develop foundation for MLR multispectral detection
- **APPROACH**
  - Use existing data for initial evaluation
    - o IR Handbook, Handbook of Spectral Data...
    - o Spectral reflectance data
    - o Measured data (Fourier Transform spectroscopy)
  - Extend existing models to multispectral domain
    - o "Flat plate" radiance model
    - o Vegetative canopy model
  - Use temperature projection to remove thermal noise

# TASK SUMMARY

- **DATA EVALUATION**
  - Spectral features exist in the thermal infrared
  - Identified fundamental physical processes that contribute to spectral structure
- **DEVELOPED BASIS OF TEMPERATURE PROJECTION ON GENERALIZED MAXIMUM LIKELIHOOD RATIO TEST**



# **TASK RESULTS**

- **MULTISPECTRAL TECHNIQUES CAN THEORETICALLY INCREASE SIGNAL TO CLUTTER GAIN BY ORDERS OF MAGNITUDE**
- **ADDITIONAL HIGH RESOLUTION DATA FOR SPECIFIC SCENARIOS ARE REQUIRED**
- **REQUIREMENTS FOR ADDITIONAL DATA ACQUISITIONS DEVELOPED**

# **CONSEQUENCES**

- **MULTISPECTRAL SENSING MAY YIELD GREATLY INCREASED DETECTION PERFORMANCE UNDER SOME CIRCUMSTANCES**
- **SMALLER (CHEAPER) MULTISPECTRAL SENSOR POSSIBLE SUBSTITUTE FOR EQUIVALENT NON-SPECTRAL SENSOR**
- **MULTISPECTRAL HAS POTENTIAL TO DETECT TARGET NOT DETECTABLE BY ANY OTHER MEANS**

# **TASK RELEVANCE**

- **MULTISPECTRAL TECHNOLOGY RELEVANT TO:**
  - **Environmental awareness**
  - **Trafficability analysis**
  - **Geologic exploration**
  - **Agricultural surveys**
- **TASK METHODOLOGY RELEVANT TO:**
  - **General automated passive remote sensing problem**
  - **Automated machine vision**
  - **Airborne/ ground based passive IR sensing**

# **STRATEGIC FORCES AND ARMS CONTROL: INFRARED SIGNATURE COMPUTER CODES**

**Presented by:**

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# CONTEXT

- **Infrared threat systems are becoming more capable as focal plane science and signal processing capability advance. Signature modification is a robust counter to these advances.**
- **IRIA has a series of codes that may be used to assess the infrared signature of objects, propagation through the atmosphere, and detection performance**
- **Key technologies: Environmental effects, materials and processes, design automation**
- **Missions:**
  - **Strategic Forces (manned bombers)**
  - **Tactical Air Forces (land and sea based)**
    - o **Reconnaissance**
    - o **Deep strike**
    - o **Air superiority**
  - **Domestic Technology Transfer**

# **IRIA SIGNATURE PREDICTION PRODUCTS**

- **TARSIS infrared signature code**
  - computes source, apparent radiance contrast
  - sensor performance
- **APART atmospheric properties code**
  - Similar to LOWTRAN
  - fully correlated band computation
  - computes background radiance
- **CREEP**
  - R&D
  - first principles coating reflectance predictions
  - unique capability
  - unclassified, but restricted distribution (preapproval required)

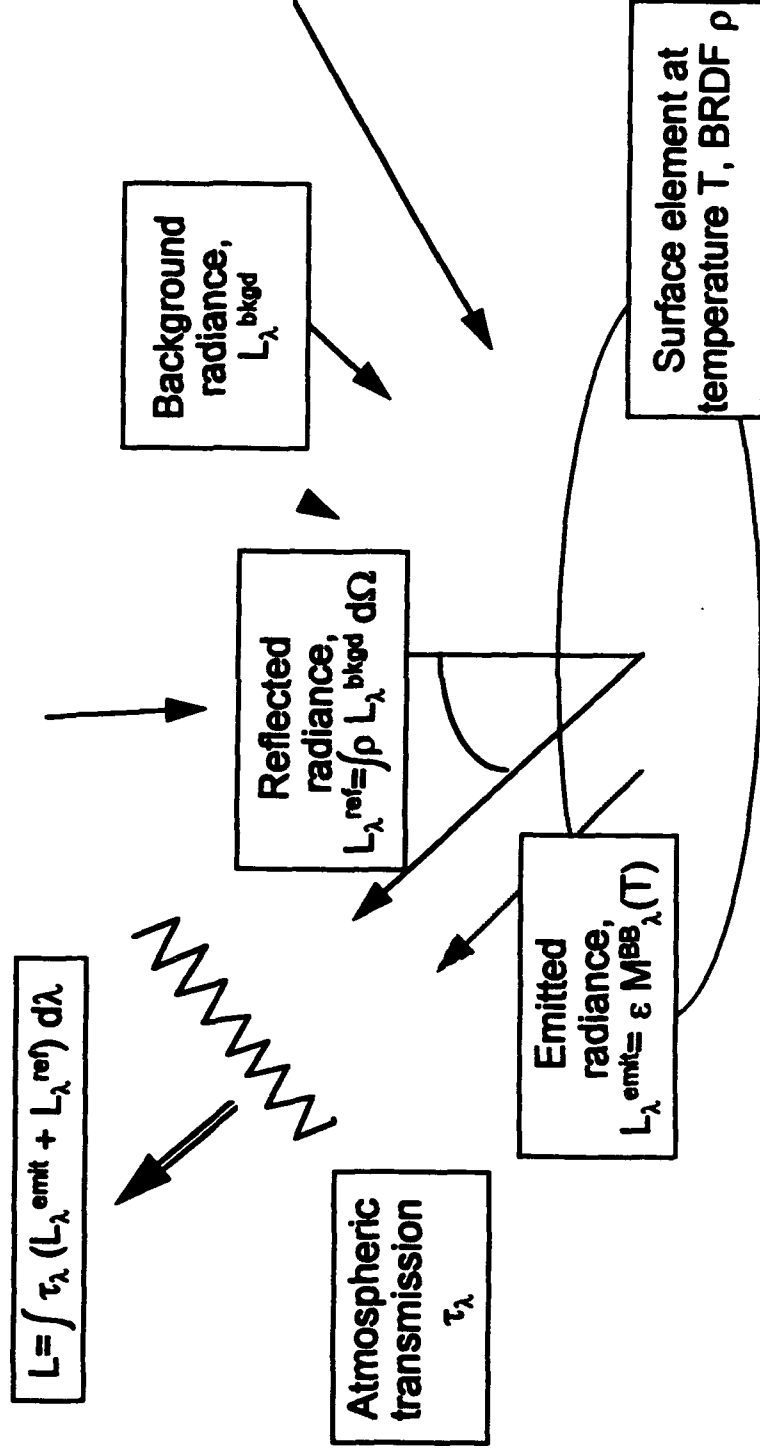


# IAC METHODOLOGY

- **CODE DEVELOPMENT**
  - Third party development
  - Government owned (or rights)
  - Modifications and improvements by ERIM
- **DISTRIBUTION**
  - Source code, object code, test cases, and documentation included.
  - Codes available for variety of machines
    - o VAX
    - o UNIX workstation (SPARC, Indigo, IRIS)
    - o PC (some codes)
  - Source code not available for CREEP

# CODE SUMMARY

- SIGNATURE PREDICTIONS
- TARSIS AND APART ADDRESS OVERALL VEHICLE AND ENVIRONMENT
- CREEP FOR COATING PREDICTIONS (BRDF)

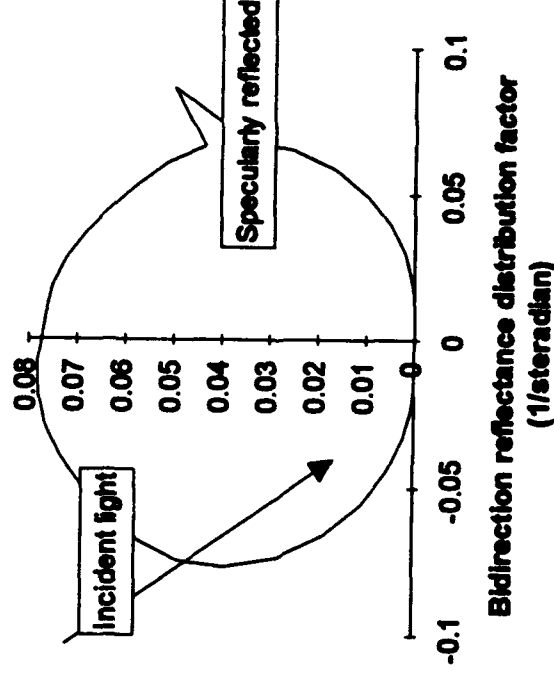


# **CREEP RESULTS**

- **CREEP ARCHITECTURE**
  - Adding /doubling method used for radiative transport
  - Scattering
    - o Closed form Mie scattering
    - o Henyey-Greenstein
    - o Specified scattering phase function
  - Surface reflectance
    - o Specular (Fresnel)
    - o Computed
      - coherent/ incoherent domains
      - two scale lengths
- **CREEP VERIFICATION AND ASSESSMENT COMPLETED**
  - Code appropriate for comparison of coating designs
  - Supporting data required for absolute predictions

# CONSEQUENCES

- **EXTENSIVE DISTRIBUTION**
  - Government
  - Industry
- **PROVIDES A CAPABILITY NOT PREVIOUSLY AVAILABLE**
  - Flexible first principles approach
  - Can be used in other spectral regimes
  - Wide application



# **TASK RELEVANCE**

- **CREEP CODE RELEVANT TO:**
  - **Sensor performance**
  - **Mission analysis**
  - **Coating design**
  - **Dual use (product appearance)**
    - o **automotive**
    - o **other consumer industries**
- **CREEP METHODOLOGY RELEVANT TO:**
  - **Environmental assessment**
  - **Terrain typing**
  - **Atmospheric modeling (clouds and other optically thick media)**

# **SENSORS AND ELECTRONIC DEVICES: INFRARED AND ELECTRO-OPTICAL SYSTEMS HANDBOOK**

**Presented by:**

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**Prepared by: R. Anderson**

**IRIA-1**

**Page 1**

# CONTEXT

- The IR/EO community needs a comprehensive reference on military sensors and electronic devices
  - The Infrared Handbook, published by the IRIA Center, has met this need in the past (more than 20,000 copies sold)
  - remains useful, but needs to be supplemented.
- The IR/EO Systems Handbook meets the current need:
  - It treats IR/EO technology relevant to most DoD thrusts, military functions and missions.
  - It was prepared by eminent authorities on each topic.
  - It is up-to-date (published in 1993).
  - It is available for public distribution.



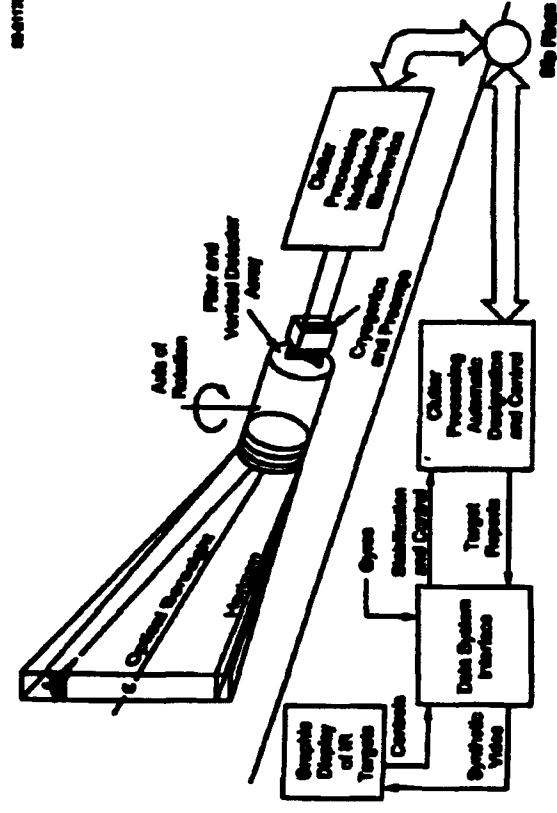


# IAC METHODOLOGY

- **METHODOLOGY USED TO PERFORM WORK**
  - Handbook chapters were prepared by recognized experts on individual topics
  - Individual chapters were reviewed by Senior Editors, and by editors of individual volumes.
- **APPROACH**
  - Handbook incorporates information from wide variety of sources (IRIS proceedings, technical reports, The Infrared Handbook, etc.)

## SUMMARY OF DATA

- **Handbook treats:**
  - **Sensor and image processing systems and components**
  - **Radiation phenomena and propagation**
  - **Military applications of IR/EO**
- **Treatment of material allows its use in the open literature.**



# RESULTS

- Handbook is being sold by IRIA and the SPIE
  - Price is moderate
- Early sales are brisk
  - Many companies are ordering multiple copies.
- Comments are favorable.

# CONSEQUENCES

- **CONTRIBUTION OF HANDBOOK**
  - Duplication of success of The Infrared Handbook anticipated.
- **OTHER BENEFITS**
  - Availability in the open literature enhances usefulness of the handbook.
  - Individual volumes are available to educational institutions.
  - Technology has potential civilian uses (dual-use technology, earth observations from space for environmental monitoring and resource management, astronomical observations, machine vision in industry, medicine, and transportation, etc.)

# **SENSORS AND ELECTRONIC DEVICES: INFRARED DATA BASES**

**Presented by:**

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# CONTEXT

- HIGH QUALITY INFRARED DATA REQUIRED TO SUPPORT  
SENSOR AND VEHICLE DESIGN EFFORTS
  - Data Requirements
    - o Experienced Experimenter
    - o Quality of Instrumentation
    - o Generality of Results
    - o Accessibility of Data
    - o Data Reviews
    - o Ground Truth
  - Simulated Data Requirements
    - o Adherence to Reality
    - o Relationship to Measured Data
    - o Value of Approximations
  - Corroboration of Measurements and Simulation
    - o Reduction of Measurement Number
    - o Improvement of Quality

# IKIA PRODUCTS

- **BACKGROUND AND TARGET DATA**
  - **HICAMP (High Altitude Calibrated Airborne Measurement Program)**
    - o Staring FPA sensor
    - o Multiple bands (filter wheel)
    - o ~750 computer tapes
  - **ERIM Sensors**
    - o Several IR line scanners
    - o Ten scenes investigated
    - o Michigan winter scene (diurnal cycle)
    - o Spatially registered
- **REFLECTANCE DATA**
  - **Spectral diffuse reflectance (FTIR)**
  - **Directional hemispheric reflectance**
  - **Bidirectional reflectance (ERIM gonioreflectometer)**
- **DATA REFERENCES AND REFERRALS**
  - **Aircraft Infrared Radiation Catalog**
  - **Indexed proceedings**
  - **Technical inquiries**

# **IRIA DATABASE METHODOLOGY**

- **COLLECT INFORMATION FROM IRIS PROCEEDINGS**
  - Review and Enter into Database
  - Disseminate in Bibliographic Form
- **COLLECT DATA FOR IRIA DATA LIBRARY**
  - HICAMP Data
  - ERIM Background Data
  - BRDF Compilation
  - Miscellaneous Databases
- **COMPILE AND UPDATE DATA REFERENCES**
- **PRODUCE HANDBOOKS, STATE-OF-THE-ART REPORTS, AND OTHER SPECIAL TOPIC REPORTS**



# RESULTS OF DATA ANALYSIS

- **FOR THE DEPARTMENT OF DEFENSE**
  - Response to procurements
  - Sensor analysis and design
  - Target and background analysis and simulation
  - Confirmation of results
- **NON-DEPARTMENT OF DEFENSE**
  - Technology transfer
    - o Many unrestricted basic research results
    - o Large requirements overlap for DoD and non-DoD
  - Shared expenses
    - o Avoidance of duplication
    - o Cost reduction

# CONSEQUENCES

- **PROMPT RESPONSE TO TECHNICAL NEEDS**
  - Immediate response to certain questions
  - Immediate reference to technical expertise
  - One- to two- day turnaround on bibliographies
  - Prompt access to special publications

# **TASK RELEVANCE**

- **DATABASE INFORMATION RELEVANT TO:**
  - Situation awareness
  - Air superiority
- **TASK METHODOLOGY RELEVANT TO:**
  - General automated passive remote sensing problem
  - Automated machine vision
  - Airborne/ ground based passive IR sensing

**RELIABLE APPLICATION OF COMPONENTS SERIES**

**(DoD KEY TECHNOLOGY: SENSORS AND  
ELECTRONIC DEVICES)**

**Prepared By**

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**Approved for Public Release: Distribution Unlimited**

# **RAC PRODUCT STRATEGY**

- **TARGET MANAGERS**

- **Awareness**
- **Impact on programs**
- **Basics**
  - o **Terminology**
  - o **Tasks**
  - o **Subtasks**
- .
- .
- .

- **TARGET DESIGNERS**

- **Impact of new technologies**
- **Design practices/guidelines**
- **Ability to trade-off alternatives**

- **TARGET R/M/Q PRACTITIONERS**

- **Procedural guides**
- **Data to support analyses**
- **Quick guides/automated tools**

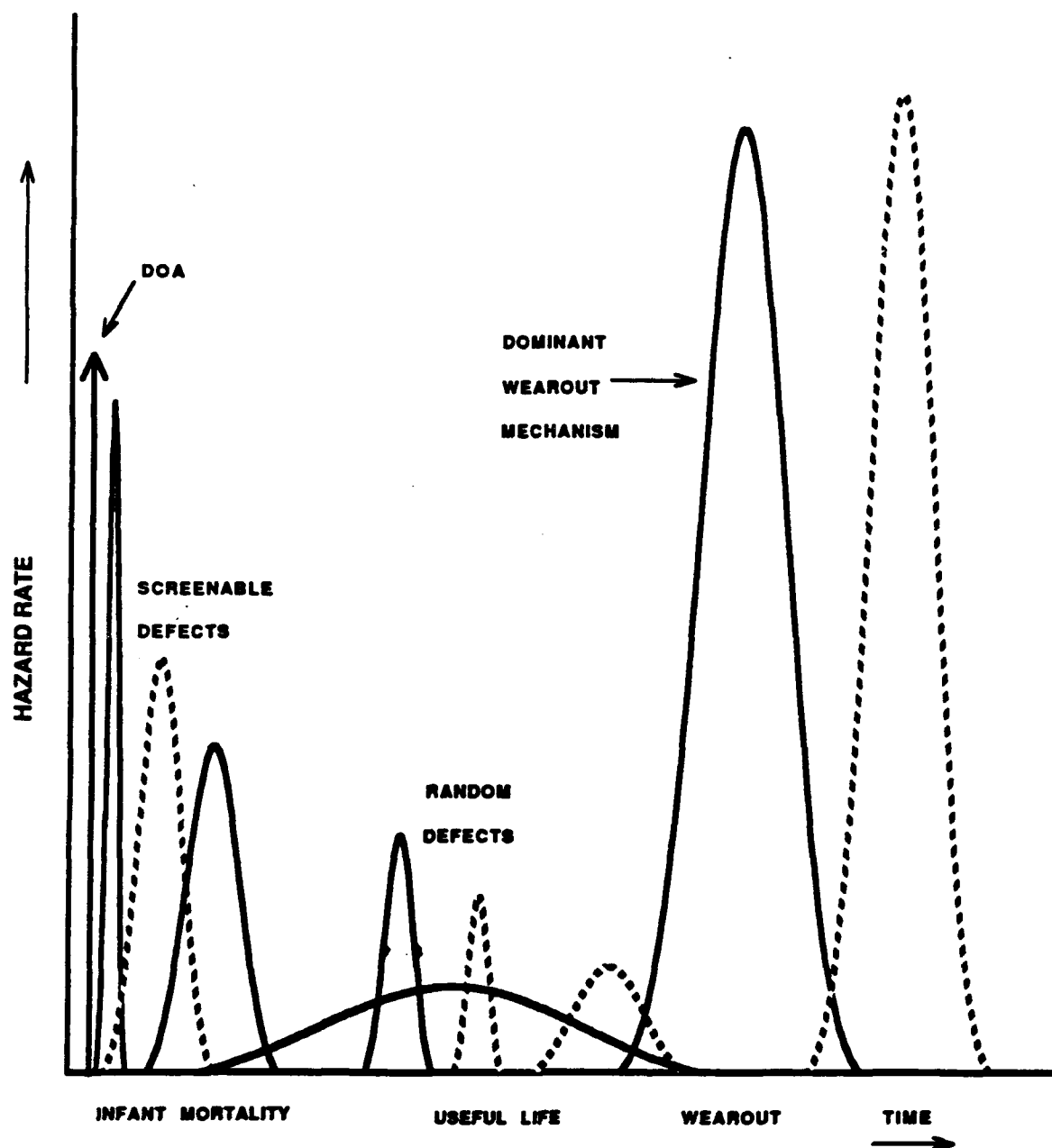
## **PRODUCT RELEVANCE**

- **DOD KEY TECHNOLOGY: SENSORS AND ELECTRONIC DEVICES**
- **PRODUCT FOCUS**
  - **Selection and control of components**
  - **Reliability considerations/limitations**
    - o **Environments**
    - o **Screening**
  - **Failure rates/mechanisms**
  - **Replace MIL-HDBK-338 "Electronic Reliability Design Handbook" (Volume II)**
- **PRODUCT IMPACT**
  - **Help use of state-of-the-art components without sacrificing reliability**

# **RELIABLE APPLICATIONS OF CAPACITORS**

- **APPLICATION INFORMATION**
  - **Environmental Considerations**
    - **Temperature Effects**
    - **Radiation Effects**
    - **Humidity**
    - **Shock/Vibration**
    - **Altitude**
  - **Electrical Considerations**
    - **Tolerance**
    - **Thermal Dissipation**
    - **Frequency**
    - **ESR**
    - **IR**
    - **DC Leakage**
    - **AC Leakage**
    - **Dielectric Absorption**
- **RELIABILITY DATA**
  - **Failure Rates**
  - **Life**
  - **Drift Characteristics**
- **FAILURE MODES**
- **SUMMARY OF RELIABILITY PROBLEMS**
- **DESIGN CONSIDERATIONS**
- **INFORMATION SOURCES**
- **DEFINITIONS**
- **INDEX (Subject)**

# **TYPICAL FAILURE MECHANISM MODEL**





# **CURRENT RAC PRODUCTS**

**DATA PUBLICATIONS** 6

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## **SPECIALIZED SERIES:**

-- **Concurrent Engineering** 5

-- **Reliable Applications of Components** 3 \*

-- **Total Quality Management Series** 3

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# **GENERIC SENSOR PACKAGE S&T ASSESSMENT FOR THE OFFICE OF NAVAL RESEARCH**

**Prepared by**

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**and**

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**Approved for Public Release: Distribution Unlimited**

[The final report for this study is Limited Distribution and/or Classified.]

# CONTEXT

- SUPPORT TO DoD S&T THRUST 2: PRECISION STRIKE, S&T THRUST 3: AIR SUPERIORITY AND DEFENSE, S&T THRUST 4: SEA CONTROL, AND S&T THRUST 5: ADVANCED LAND COMBAT
- RELEVANT TO DoD KEY TECHNOLOGY 3: SENSORS
- DoD MILITARY MISSIONS/FUNCTIONS: GROUND FORCES/CLOSE AIR SUPPORT, TACTICAL LAND-BASED AIR FORCES, TACTICAL SEA-BASED AIR FORCES
- THE PURPOSE OF THIS EFFORT WAS TO CREATE A POINT PAPER FOR ONR TO BE REVIEWED BY NAVAIR, AND THE ENTITIES WHICH ADDRESSED THE POTENTIAL FOR A GENERIC SENSOR PACKAGE WHICH COULD BE UTILIZED IN CURRENT AND FUTURE NAVAL AIRFRAMES (S3, P3, F/A-18, F-14, ANY NGW START)

Prepared by: J. McCasland-Battelle/  
L. W. Williams-TWSTIAC

TWSTIAC-2

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## **CONTEXT (Continued)**

- THE INPUT FOR THIS OVERALL EFFORT CAME FROM TWO MAJOR SOURCES (1) EXTERNAL TO THE GOVERNMENT (INDUSTRY) AND (2) INTERNAL TO THE GOVERNMENT (LARS, NAWC, WPAFB, ARDA, ETC.)
- INDUSTRY RESPONSE WAS SOLICITED IN THE TRADITIONAL CBD APPROACH
- TWSTIAC WAS TASKED TO SUPPORT THE INTERNAL RESPONSE

Prepared by: J. McCasland-Battelle/  
L. W. Williams-TWSTIAC

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# TWSTIAC TASK

- THE KIND OF INSIGHTS SOUGHT BY ONR IN THIS EFFORT WOULD HELP ADDRESS/ANSWER QUESTIONS SUCH AS:

- (1) With the threats/targets/environment currently envisioned are there current on-going sensor developments that should be singled out and pushed (fully funded), which would result in a very significant improvement that would translate to much higher leverage on the battlefield?
  - (2) Given the status of current developments, what would be the results of waiting 5 years as technology progressed and then providing funding for Engineering & Manufacturing Development to achieve high leverage in (1) above?
  - (3) Same as (2), but delay 10 years
- SENSOR DEVELOPMENTS ADDRESSED TO INCLUDE ALL SERVICES AND ALL SENSOR AREAS (ACQUISITION, STRIKE, ETC.)

Prepared by: J. McCasland-Battelle/  
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## **TWSTIAC TASK (Continued)**

- **HELP IDENTIFY THOSE SENSOR DEVELOPMENTS THAT NOT ONLY SHOW PROMISE BUT ALSO THOSE EFFORTS THAT WOULD SHOW PROMISE IF BETTER PROGRAM INTEGRATION WERE EXERCISED**

Prepared by: J. McCasland-Battelle/  
L. W. Williams-TWSTIAC

TWSTIAC-5

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# TWSTIAC METHODOLOGY

- DATA COLLECTION

- Data collection for sensor S&T assessments consisted of visits to Government labs/offices and documentation review. The two prime sources in each area are:

- Visits: NAWC Warminster
- Documents: Fiscal year 1994 (FY 94) Joint Service Program Plan Technology Panel for Sensors (JDL-TDSE)

- DATA ANALYSIS

- Sensor development project efforts were reviewed and assessed by TWSTIAC experts in each area of endeavor (radar, IR, laser, Etc.) providing their perspectives and insights

Prepared by: J. McCasland-Battelle/  
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# **TWSTIAC METHODOLOGY**

## **(Continued)**

- **DATA SYNTHESIS**

- Armed with the viewpoint/perspectives of the results of the data analysis a review of the goals/priorities/schedule in a project related to similar efforts as well as efforts that used a different technology or different approach but were trying to achieve the same end results. Program integration between services relative to each service's project priorities was a big factor in the synthesis

Prepared by: J. McCasland-Battelle/  
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## APPROACH

- EARLY IN THIS EFFORT IT WAS EVIDENT THAT THE FUTURE WORLD IN WHICH WE MIGHT HAVE TO CONDUCT BATTLEFIELD OPS HAD TO BE NARROWED TO A TARGET MATRIX THAT WAS REPRESENTATIVE BUT NOT SO BIG THAT THE STUDY WOULD GET BOGGED DOWN.
- THE MAIN SOURCES OF INFORMATION WERE AS DESCRIBED ABOVE
- THE "NEW" INFORMATION THAT RESULTED FROM THIS ASSESSMENT WAS THE IDENTIFICATION OF THOSE SENSOR DEVELOPMENTS EFFORTS THAT HAD "BREAK- THROUGH POTENTIAL" RELATIVE ACHIEVING HIGH BATTLEFIELD LEVERAGE AGAINST THE THREAT MATRIX MENTIONED ABOVE.

Prepared by: J. McCasland-Battelle/  
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## **SUMMARY OF DATA**

- **FOURTEEN CATEGORIES OF SENSOR DEVELOPMENTS WERE ADDRESSED IN THE FOLLOWING SUBAREAS:**

- **Airborne Wide Area Surveillance (WAS) Radar (ZANF)**
- **OTH Land Based Radar**
- **Wide-Area Surveillance Electro-Optic(EO)**
- **Air-Air/Air-Surface Radar**
- **Strike Radar (ZANF)**
- **Nap-of-Earth Radar**
- **Anti-Submarine Warfare**
- **Surface-Surface, Surface-to-Air Radar (Sea Based)**
- **Air-Air and Air-Surface Electro-Optics**
- **Anti-Surface Electro-Optics (ZANF) (Joint)**
- **Anti-Surface Electro-Optics (Individual Services)**
- **Surface-Surface/Surface-Air Electro-Optics (Sea Based)**
- **Automatic Target Recognition (ATR) Technology**
- **JDL Multi-Color IR Technology Working Group**

**Prepared by: J. McCasland-Battelle/  
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# **SUMMARY OF DATA**

## **(Continued)**

- **IN SOME CASES WHOLE CATEGORIES DID NOT CONTAIN DEVELOPMENTS ORIENTED TO THE GENERIC SENSOR PACKAGE THREAT MATRIX (TELS, TBMS, VLO TGTS) SUCH AS ANTI-SUBMARINE WARFARE**
- **ALL WERE ASSESSED FOR AIR PLATFORM CARRIAGE**
- **OUT OF THE ABOVE A TOTAL OF 62 SPECIFIC DEVELOPMENTS OR GROUPINGS OF DEVELOPMENTS HAD POTENTIAL FOR PROVIDING A DIRECT OR INDIRECT POSITIVE INFLUENCE**

Prepared by: J. McCasland-Battelle/  
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## RESULTS OF DATA ANALYSIS

- THE SENSOR DEVELOPMENT PROGRAM/PROJECT ENDEAVORS WERE ASSESSED WITH RESPECT TO THEIR "BREAK-THROUGH POTENTIAL" RELATIVE TO PRODUCING THE KIND OF PERFORMANCE IMPROVEMENTS THAT COULD RESULT IN THE BATTLEFIELD LEVERAGE PREVIOUSLY MENTIONED
- SOME OF THESE EFFORTS WERE NOT CLEAR-CUT BLACK/WHITE DECISIONS. FOR EXAMPLE SOME EFFORTS THAT WERE EVALUATED AS HIGH AGAINST VLO AIR TARGETS WERE EVALUATED AS LOW AGAINST THE REST OF THE THREATS (TBMS, TELS). ALSO SOME EFFORTS EXHIBITED GOOD (HIGH) ATTRIBUTES FOR ONE PARTICULAR FACTOR SUCH AS SENSOR-TO-SENSOR KEYING BUT FELL DOWN IN OTHER AREAS. THE "BREAK-THROUGH POTENTIAL" THAT THESE EFFORTS WERE ASSIGNED WAS BASED ON THEIR POTENTIAL TO CONTRIBUTE TO THE ENTIRE THREAT MATRIX

# RESULTS OF DATA ANALYSIS (Continued)

- THE SIXTY-TWO (62) EFFORTS ASSESSED WERE EVALUATED AS FOLLOWS

Break-through Potential Assessment Rating	Number
High	14
Moderate-high	16
Moderate	4
Low-moderate	10
Low	18

- FOR EACH DEVELOPMENT EFFORT THE GOAL/OBJECTIVE AND TIME FRAME FOR COMPLETION WAS STATED

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## **CONSEQUENCES**

- **FULL IMPACT OF THIS EFFORT WILL NOT BE CLEARLY EVIDENT UNTIL ONR'S INTERNAL ASSESSMENT CAN BE ADDRESSED IN CONTEXT WITH THE INDUSTRIAL RESPONSE**
- **BENEFITS TO DOD WILL COME IN THE VISIBILITY TO ADDRESS AND PROVIDE PROGRAM INTEGRATION WHERE IT IS NEEDED TO MAKE THINGS HAPPEN**
- **THE ABOVE WILL IN TURN PROVIDE THE COST SAVINGS TO NAVAIR IN TERMS OF IDENTIFYING THE MOST EFFECTIVE TECHNOLOGY INFUSION PROGRAMS TO PURSUE**
- **ACCELERATION AND SUCCESSFUL COMPLETION OF PROGRAM MILESTONES**
- **REVIEW OF OPERATIONS PURSUANT TO SENSOR CAPABILITIES EXISTENT ON A LARGER VARIETY OF AIRFRAMES/PLATFORMS**

**Prepared by: J. McCasland-Battelle/  
L. W. Williams-TWSTIAC**

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## **RELEVANCE TO OTHER USERS**

- **AS "NEW START" PROGRAMS BECOME FEWER AND HARDER TO IMPLEMENT, THIS TYPE OF EXERCISE WILL BE IMPORTANT ACROSS ALL DOD SERVICES AND WEAPON SYSTEMS**
- **THIS TYPE OF ENDEAVOR HIGHLIGHTS WHERE "PROGRAM INTEGRATION" IS NEEDED IN ADDITION TO ADDRESSING THE TECHNICAL MERITS OF A PARTICULAR DEVELOPMENT**

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**TWSTIAC-14**

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# **ASSESSMENT OF ULTRA-WIDEBAND (UWB) RADAR TECHNOLOGY**

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**Approved for Public Release: Distribution Unlimited**

[The final report for this study is Limited Distribution and/or Classified. AD B146 160]



## **CONTEXT**

- **DoD S&T THRUSTS 1: GLOBAL SURVEILLANCE AND COMMUNICATIONS, 2: PRECISION STRIKE, AND 3: AIR SUPERIORITY AND DEFENSE**
- **DoD KEY TECHNOLOGIES: SENSORS/RADAR SENSOR TECHNOLOGY**
- **DoD MILITARY MISSIONS/FUNCTIONS: STRATEGIC FORCES, AIR DEFENSE**

Prepared by: V. G. Pugliese-Battelle/  
L. W. Williams-TWSTIAC

TWSTIAC-2

Pugliese, V.G.

# **TWSTIAC TASK/BASIC INFORMATION PRODUCT**

## **TWSTIAC WAS ASKED TO:**

- **EXAMINE THE STATE OF THE ART AND POTENTIAL BENEFITS OF UWB TECHNOLOGY, PARTICULARLY FOR RADAR APPLICATIONS**
- **IDENTIFY AND PRIORITIZE RESEARCH TO BE PURSUED**

**Prepared by: V. G. Puglielli-Battelle/  
L. W. Williams-TWSTIAC**

**TWSTIAC-3**

**Puglielli.vu**

# **TWSTIAC METHODOLOGY**

- **BLUE RIBBON PANEL OF RESIDENT AND NATIONAL EXPERTS ON UWB TECHNOLOGY AND RADAR**
- **REVIEWED PRIOR UWB RADAR DEVELOPMENT**
  - **Experimental data**
  - **Literature--including Soviet**
- **REVIEWED ONGOING AND PROPOSED WORK**
  - **Government laboratories**
  - **Industry and academia**
- **DETERMINED POTENTIAL PERFORMANCE BENEFITS**
  - **Radar technologies, including against low-observable targets**
  - **Countermeasures, especially probability of detection**

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L. W. Williams-TWSTIAC

TWSTIAC-4

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## **TWSTIAC METHODOLOGY (Continued)**

- **IDENTIFIED TECHNOLOGY ISSUES/GAPS IN KNOWLEDGE/  
PRIORITY OF IMPORTANCE**
- **RECOMMENDED NEEDED RESEARCH**
  - **Areas for further investigation**
  - **Experimental tools/hardware needed**
- **DETERMINED POSSIBLE APPLICATIONS**

**Prepared by: V. G. Pugliesi-Battelle/  
L. W. Williams-TWSTIAC**

**TWSTIAC-5**

**Pugliesi, VU**

# **ASSISTANCE DELIVERED**

- **CONCENTRATED ON CHARACTERISTICS OF AND CLAIMS MADE FOR UWB TECHNOLOGY: RADAR, COMMUNICATIONS, ELECTRONIC WARFARE AND RF WEAPONIZATION**
  - **No applications were advanced for communications**
  - **Government in-house committee was addressing applications to EW and RF weaponization**
  - **Therefore, this study concentrated on radar applications**
- **FOCUSED ON CLAIMS FOR ULTRA-WIDEBAND "IMPULSE" RADAR AS BEING INHERENTLY:**
  - **Counter-stealth (i.e., to defeat the F-117 and the B-2)**
  - **Low Probability of Intercept (LPI) (to defeat countermeasures)**
  - **Capable of detecting relocatable targets in camouflage/foilage**
- **REVIEWED THE THEORETICAL BASES FOR CLAIMED CAPABILITIES**

Prepared by: V. G. Pugliese-Battelle/  
L. W. Williams-TWSTIAC

TWSTIAC-6

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## **RESULTS OF DATA ANALYSIS**

- **IMPULSE RADAR IS NOT INHERENTLY COUNTER-STEALTH**
  - Conventional radars are able to exploit any vulnerabilities resulting from target shaping
  - No effects in RAM are unique to impulse radar
- **IMPULSE RADAR IS NOT INHERENTLY DIFFICULT TO DETECT**
  - It is difficult to make any radar hard to detect
  - Impulse radar has no special LPI characteristics, is readily detected by an appropriately designed intercept receiver
- **A PROPERLY DESIGNED IMPULSE RADAR MIGHT BE ABLE TO DETECT TARGETS SHIELDED BEHIND TREES (AS MIGHT ANY NON-IMPULSE UWB RADAR)**

Prepared by: V. G. Puglielli-Battelle/  
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## **RESULTS (Continued)**

- **ADVANCES IN SOURCES FOR VERY HIGH POWER SHORT PULSES MIGHT BENEFIT CONVENTIONAL SHORT PULSE RADAR AS WELL AS IMPULSE TRANSMITTERS**
- **CONVENTIONAL RADAR THEORY IS COMPLETELY ADEQUATE FOR UNDERSTANDING IMPULSE RADAR PHENOMENA--THERE IS NO UNIQUE THEORETICAL BASIS FOR UWB RADAR**
- **RECOMMENDATIONS WERE MADE:**
  - **Do analyses of point designs using both impulse and non-impulse radar approaches for four military applications**
  - **Do studies of clutter behavior of UWB radar systems and characteristics of UWB antennas**
  - **Do a modest study to document characteristics of self-induced transparency and other non-linear effects possibly relevant to military systems**

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## **CONCLUSIONS**

- **INTERESTING WORK WAS UNDER WAY, AND SELECTED/LIMITED R&D INVESTMENTS COULD EXPLORE ITS POTENTIAL BENEFITS**
- **IMPULSE RADAR DOES NOT OFFER A MAJOR NEW MILITARY CAPABILITY, NOR DOES IT THREATEN A SERIOUS TECHNOLOGICAL SURPRISE**

Prepared by: V. G. Puglielli-Battelle/  
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TWSTIAC-9

Puglielli vu



# CONSEQUENCES

- **WHAT HAS HAPPENED AS A RESULT OF THIS EFFORT?**

- **Financial benefits to DoD**

- Congress had mandated \$25M FY90 funds be spent on this technology. This effort helped to focus investment of \$10M FY90-91 and \$12M FY92-93 funding for UWB into theoretically sound, technologically promising, and operationally appropriate R&D
- Avoided "Loss Leader" construction of an unnecessary UWB radar site-- future investments could have been multiples of \$25M

- **Other benefits to DoD**

- Disproved unfounded challenges against the viability of stealth technologies
- Discredited claims that the U.S. was at risk of major technological surprise
- Brought some discipline and technical foundation to a highly visible, poorly described technology as an aid to decision makers
- Laid the foundation for subsequent technology developments which are significant for several applications, the most notable proving to be foliage penetration radar.

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Pugliese, vu

## **RELEVANCE TO OTHER USERS**

- **THE METHODOLOGY OF A "BLUE RIBBON" TEAM OF HIGH QUALITY/INTEGRITY UNDER IMPARTIAL ORGANIZATIONAL LEADERSHIP CAN BE APPLIED TO ANY PROBLEM WHERE TECHNICAL CONFUSION IS WIDESPREAD AND UNUSUAL CLAIMS MAY BE THE BASIS FOR DoD INVESTMENT**
- **THE REPORT STANDS AS A SOUND GUIDE FOR FUTURE PLANNERS IN THIS TECHNOLOGY. THE BASIC PHYSICS WHICH FORMS THE REPORT'S FOUNDATION WILL NOT CHANGE WITH TIME. THE TECHNOLOGY CONTINUES TO ADVANCE ALONG THE LINES PREDICTED.**

**Prepared by: V. G. Pugliese-Battelle/  
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**TWSTIAC-11**

**Pugliese, vu**

# COMMUNICATIONS NETWORKING

# **TWSTIAC SUPPORT TO DEVELOPMENT OF A NETWORKED CD-ROM DATABASE**

**Prepared by**

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**Approved for Public Release: Distribution Unlimited**

[The final report for this study is Limited Distribution and/or Classified.]

# CONTEXT

- S&T THRUST 7: TECHNOLOGY FOR AFFORDABILITY
- DoD KEY TECHNOLOGIES 1, 2, AND 4: COMPUTERS, SOFTWARE, AND COMMUNICATIONS NETWORKING
  - "... to advance the state of the art and state of the practice of data, information, and signal processing for military missions and systems."
  - "... the timely generation, maintenance, and enhancement of affordable and reliable applications software... For distributed systems..."
  - "... shared communications media and common hardware and applications software to enable the timely, reliable, and secure production and worldwide dissemination of information..."

Prepared by: J. Dorsey-DTIC/  
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L. W. Williams-TWSTIAC

TWSTIAC-2

Dorsey vu

# **TWSTIAC PRODUCT**

- **DTIC REQUIRES A SYSTEM ARCHITECTURE FOR A CD-ROM-BASED INFORMATION SYSTEM**
  - **For storage, search, and retrieval**
  - **Of full text publications, indexes, and graphics**
  - **Compatible with the existing DTIC LAN**
  - **Providing simultaneous, multi-user multi-platform access**
  - **To DTIC offices and staff of the Office of the Undersecretary of Defense for Acquisitions and Technology**

**Prepared by: J. Dorsey-DTIC/  
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L. W. Williams-TWSTIAC**

**TWSTIAC-3**

**Dorsey.vu**

# **TWSTIAC METHODOLOGY**

- **REVIEW TECHNICAL LITERATURE ON CD-ROM DATABASES**
- **DO A SYSTEMS ANALYSIS OF EXISTING DTIC NETWORK**
- **PROVIDE OPTIONS FOR IMPLEMENTING CD-ROM VIA THE DTIC NETWORK**
- **SPECIFY METHODS FOR SUPPORTING ACCESS TO THE CD-ROM APPLICATIONS BY DIVERSE OPERATING SYSTEMS**
- **PROVIDE ALTERNATIVE SYSTEM CONFIGURATIONS, IMPLEMENTATION PLAN, AND EQUIPMENT LIST**
- **PERFORM SHAKEDOWN OPERATION OF THE INSTALLED SYSTEM**

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TWSTIAC-4

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# **DATA ANALYSIS**

- **CHARACTERIZED DTIC LAN USER ENVIRONMENT**
- **IDENTIFIED CONSIDERATIONS AND OPTIONS FOR IMPLEMENTING ACCESS BY DIVERSE OPERATING SYSTEMS**
- **RECOMMENDED SYSTEM ARCHITECTURES**
- **RECOMMENDED EQUIPMENT TO SUPPORT THE SOLUTION**

Prepared by: J. Dorsey-DTIC/  
H. McQueen-CD Consultants, Inc./  
L. W. Williams-TWSTIAC

TWSTIAC-5

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# CONSEQUENCES

- **SIGNIFICANT COST SAVINGS ARE PROJECTED**
  - **Electronic data transfer will replace hardcopy printing/transporting**
  - **Reduced number of personnel interventions**
  - **Real-time system response to requirer of information/data**
  - **Save 40-56 minutes of staff time per search--system will pay for itself after 2,666 searches**

Prepared by: J. Dorsey-DTIC/  
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TWSTIAC-6

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## **CONSEQUENCES (Continued)**

- **OTHER BENEFITS INCLUDE**

- **Synergy with rapidly growing commerical CD-ROM information industry**
- **Integrated searching tool will provide single-search access to multiple sources**
- **Will allow DTIC to more rapidly bring on-line new information received and new information sources**

- **ANTICIPATED CHANGES IN DTIC OPERATIONS**

- **Greater flexibility in meeting subscribers' needs**
- **Greater responsiveness in meeting DoD requirements (e.g., in changing Military Standards)**

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TWSTIAC-7

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## **RELEVANCE TO OTHER USERS**

**THIS SOLUTION WILL BE ADVANTAGEOUS TO OTHERS WHO NEED  
TO TRANSMIT CD-ROM BASED IMAGES OVER LAN'S OR T-1 LINES  
ALREADY SATURATED WITH HIGHER PRIORITY TRAFFIC**

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TWSTIAC-8

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# **ISSUES FACING NETWORK IMPLEMENTATION**

- **DOS SEARCH/RETRIEVAL SOFTWARE REQUIRES ~490K RAM IN CLIENT (PENTAGON WORKSTATIONS MAY BE A PROBLEM)**
- **NETBIOS (LAN MAN AND PATHWORKS) IS THE ONLY COMMON NETWORKING PROTOCOL**
- **SUGGESTED CONFIGURATION:**
  - **Magnetic indexes at both sites**
  - **Shared image server**
  - **87 + CD-ROM image discs**
- **WHAT'S MISSING FROM THE SOLUTION**
  - **Windows search/retrieval interface**
  - **CD-ROM networking software which can translate between 87 consecutive image discs**

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TWSTIAC-9

Dorsey.vu



# **COMPUTERS & SOFTWARE COMMUNICATIONS NETWORKING**

**Prepared by**

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**Approved for Public Release: Distribution Unlimited**

# **CONTEXT**

- **COMPUTERS & SOFTWARE**

- High performance computing systems providing orders of magnitude improvements in Modeling & Simulation

- **COMMUNICATIONS NETWORKING**

- The timely, reliable, and secure production and worldwide dissemination of information using shared communications media and common hardware and application software, organized/managed through established standards and protocols in support of Training, Military Operations, and Research, Development, & Acquisition (RDA)

# **TWSTIAC PRODUCTS**

- **INFORMATION ON ADVANCED APPLICATIONS OF DISTRIBUTED SYSTEMS AND NETWORKING TECHNOLOGY**
  - **Catalog of program applications**
  - **DIS Test Bed**
  - **IEEE DIS Standards & Protocols**
- **DIS EDUCATION / WORKSHOPS**
  - **Standards Workshops**
  - **User Application Workshops**
  - **Computer Generated Forces (CGF) Workshops**

# **METHODOLOGY**

- **VARIETY OF METHODS USED, INCLUDING ...**
  - Survey of key Users / Developers
  - Analysis based on expert panel, peer review, & technical assessments
  - Research on entity representation & alternative networking
- **APPROACH: TRADITIONAL MIXED WITH NEW IDEAS**
  - Applications of DELPHI technique to establish priorities
  - Electronic "Town Meetings" focused on special interest groups
  - Expert seminars organized in conjunction with national conferences; e.g., I/ITSEC, AUSA
  - User workshops geared to change the way Users think and introduce new paradigms for leveraging efforts



## **SUMMARY OF DATA**

- **DATA COLLECTION CATEGORIES**
  - Expert Points of Contact
  - “LESSONS LEARNED” on research findings
  - Key research initiatives sorted by requirements
  - Standards and protocols for networked applications
  - Service and DOD regulatory requirements
  - Key Industry members in the communications field
- **INTERESTING CHARACTERISTICS**
  - Inconsistency in data elements across Users
  - “FEAST OR FAMINE” population of data across areas
  - Lack of configuration control on data
  - Breadth & diversity of Users
  - Volume & quantity of data

# **RESULTS OF DATA ANALYSIS**

- **FINDINGS**

- Condition of networking is of such diversity that linkages can only be accomplished via standard protocols
- Methods of sharing networking solutions are not widely publicized
- Interservice solutions are rare

- **SUMMARY OF TECHNICAL RECOMMENDATIONS**

- Policy on standards in applications must be developed to recognize variety of previous applications
- Standards of data, database design, and horizontal integration are needed to meet the operational needs of Users

## **ELECTRONIC DEVICES**

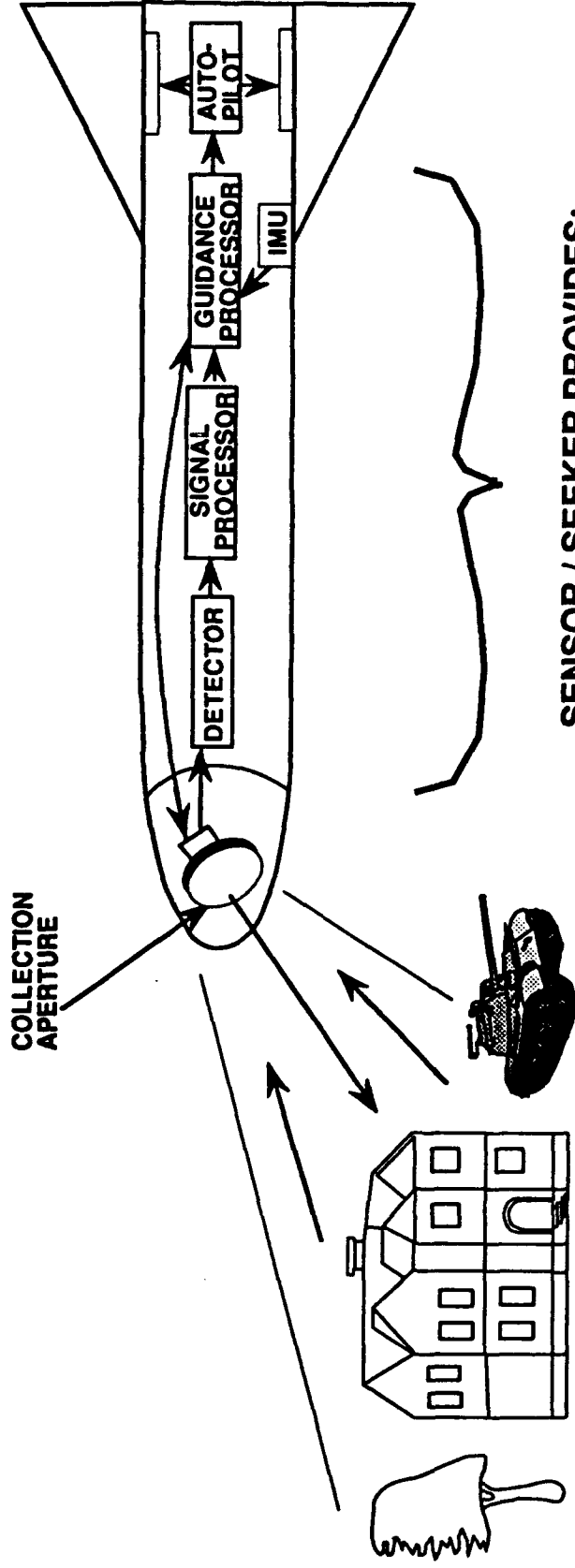


# **SENSORS AND ELECTRONIC DEVICES**

**PREPARED BY  
DR. ROBERT J. HEASTON**

**GUIDANCE AND CONTROL INFORMATION ANALYSIS CENTER  
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# SEEKERS / SENSORS CONTEXT



## SENSOR / SEEKER PROVIDES:

- SENSING OF TARGET ATTRIBUTE IN THE DETECTOR -- USUALLY SOME FORM OF EMITTED OR REFLECTED ENERGY.
- TARGET DETECTION DECISIONS IN THE SIGNAL PROCESSOR BASED ON TRANSDUCED SIGNALS FROM THE DETECTOR.
- RELATIVE TARGET POSITION BASED ON APERTURE LINE-OF-SIGHT AND TRACKING ALGORITHMS IN THE SIGNAL PROCESSOR SEEKER/SENSOR.

SENSOR FOOTPRINT  
INCLUDES  
TARGET + CLUTTER  
ATTRIBUTES



# REPRESENTATIVE SEEKER/SENSOR ANALYSIS EFFORTS

## TITLE

MULTISPECTRAL AIR-TO-AIR SEEKER (MSAAS)  
 SMART TACTICAL AUTONOMOUS GUIDANCE (STAG)  
 LOW COST ANTI-ARMOR SUBMUNITION (LOCAAS)  
 LINE-OF-SIGHT ANTI-TANK (LOSAT) ANALYSIS  
 ADVANCED SENSOR/SEEKER DEVELOPMENT  
 BAT PREPLANNED PRODUCT IMPROVEMENT (P3I)  
 US/JAPAN DUAL MODE SEEKER COOPERATIVE EFFORT  
 BLUE VEHICLE SURVIVABILITY ASSESSMENT  
 PASSIVE DET, TRKG, & ID -- GROUND VEHICLES  
 FIELD DEMONSTRATION OF ACOUSTIC TRACKER  
 MULTI SENSOR/TARGET TRACKING

SENSOR/SEEKERS  
 IMAGING INFRARED  
 ACTIVE / PASSIVE MMW  
 ACOUSTIC  
 ASER RADAR  
 MULTIMODE / DUAL MODE  
ALGORITHMS - ATR  
 IMAGE PROCESSING  
 NEURAL NETWORKS  
 DATA FUSION  
SIGNATURES  
 DATA COLLECTION  
 STRUCTURING & COMPILATION  
 CHICKEN LITTLE DATA  
TEST & EVAL  
 LABORATORY  
 FIELD (TOWER & CFT)  
 HWIL

## MULTIPLE CUSTOMERS

MULTIPLE SERVICES (ARMY, AIR FORCE, NAVY)  
 DTIC  
 ARPA  
 RESEARCH, DEVELOPMENT, & ENGINEERING CENTERS  
 LABORATORIES  
 PROGRAM EXECUTIVE OFFICES  
 PROGRAM MANAGEMENT OFFICES

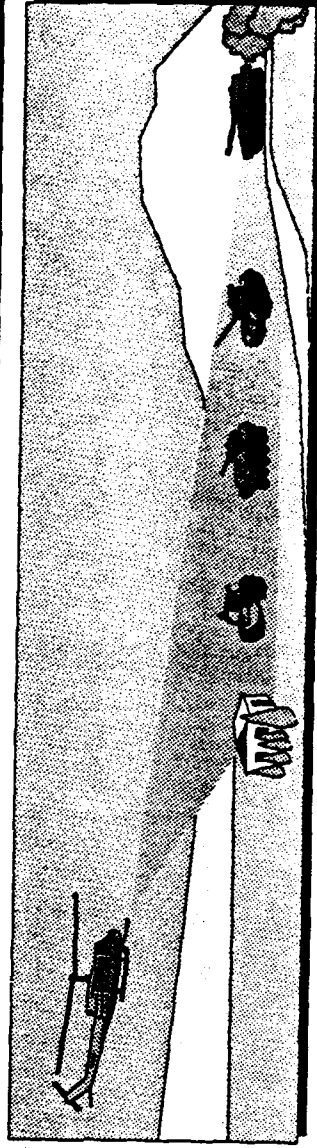
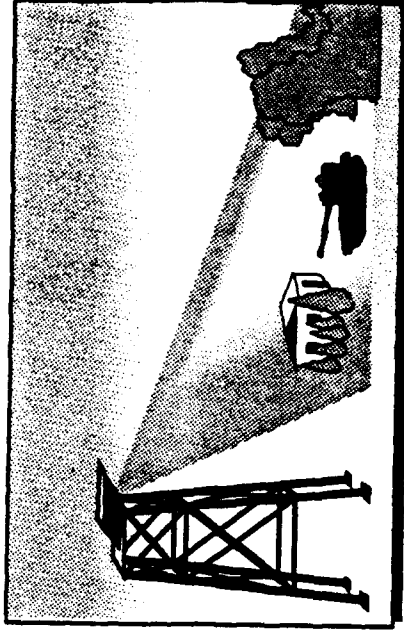
Presented by  
 15  
**CACAC**  
 DE HUNTERSTON

# INDEPENDENT SEEKER / SENSOR ANALYSES

## OBJECTIVE:

PROVIDE INDEPENDENT ANALYSIS AND ASSESSMENTS OF POTENTIAL CAPABILITIES OF VARIOUS TYPES OF SENSORS

- MMW/PASSIVE MMW
- LADAR
- INFRARED
- ACOUSTIC
- MULTI-MODE/DUAL MODE

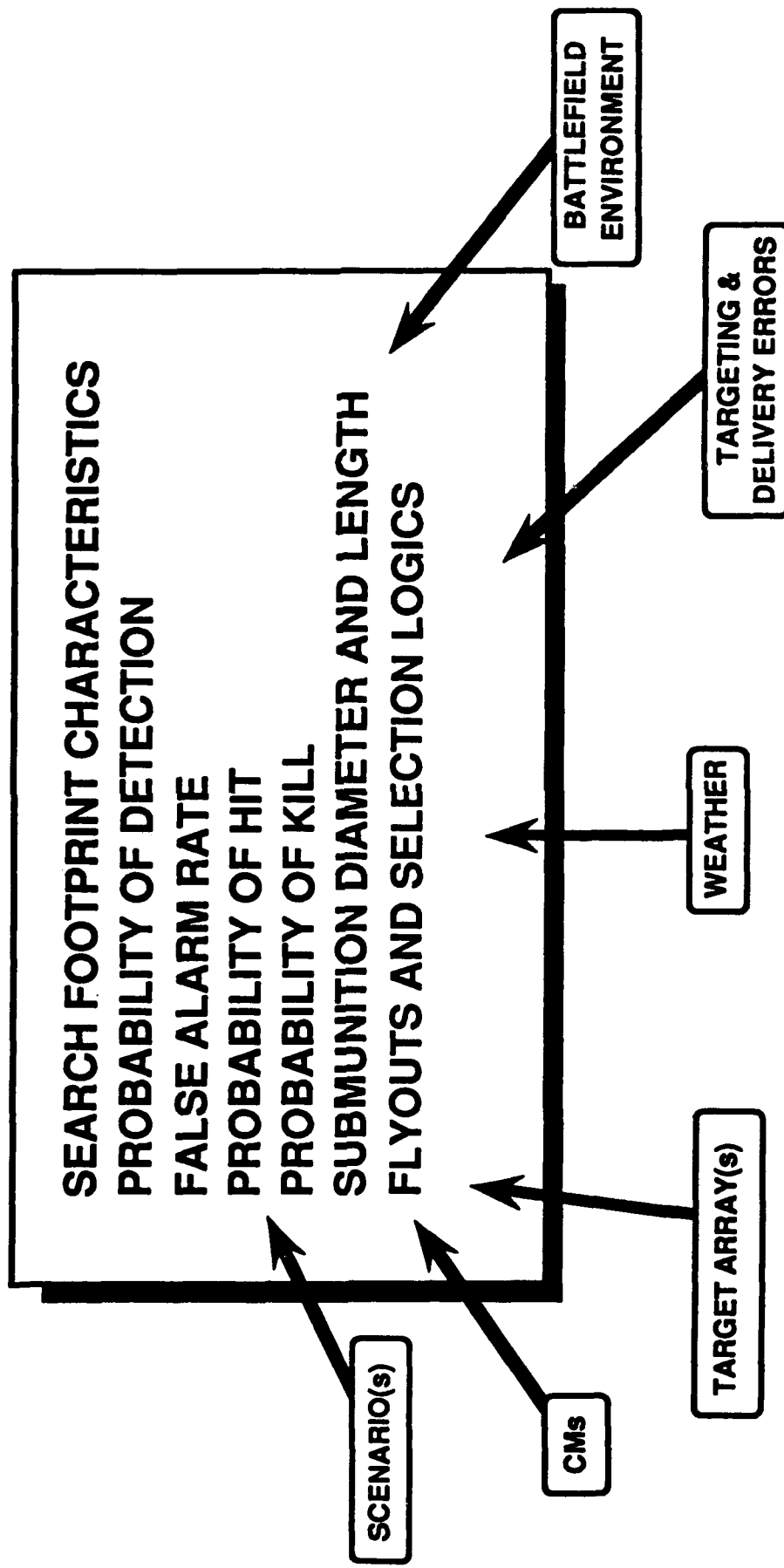


## ACTIVITIES:

- ASSIST IN TOWER AND CAPTIVE FLIGHT TEST PLANNING
- PERFORM ASSESSMENT OF SENSORS' PERFORMANCE IN FIELD TESTS (TOWER AND CAPTIVE FLIGHT TEST MANEUVERS)
- PERFORM HARDWARE AND ALGORITHM DESIGN ASSESSMENTS
- IDENTIFY STRENGTHS / WEAKNESSES OF THE SENSORS' DESIGNS

Presented By: **GACIAC**  
DR. R. J. HEASTON

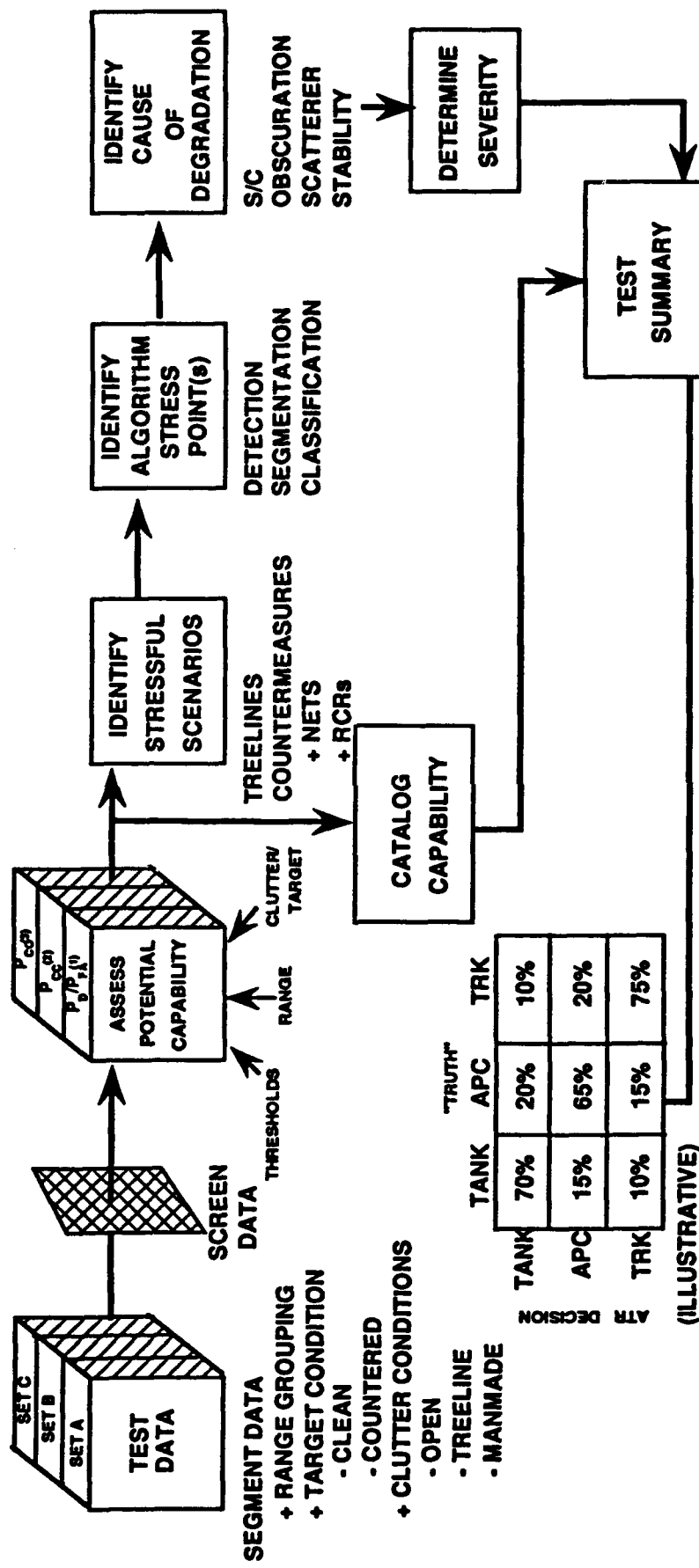
# FACTORS AFFECTING SEEKER / SENSOR PERFORMANCE



SEEKER / SENSOR PERFORMANCE



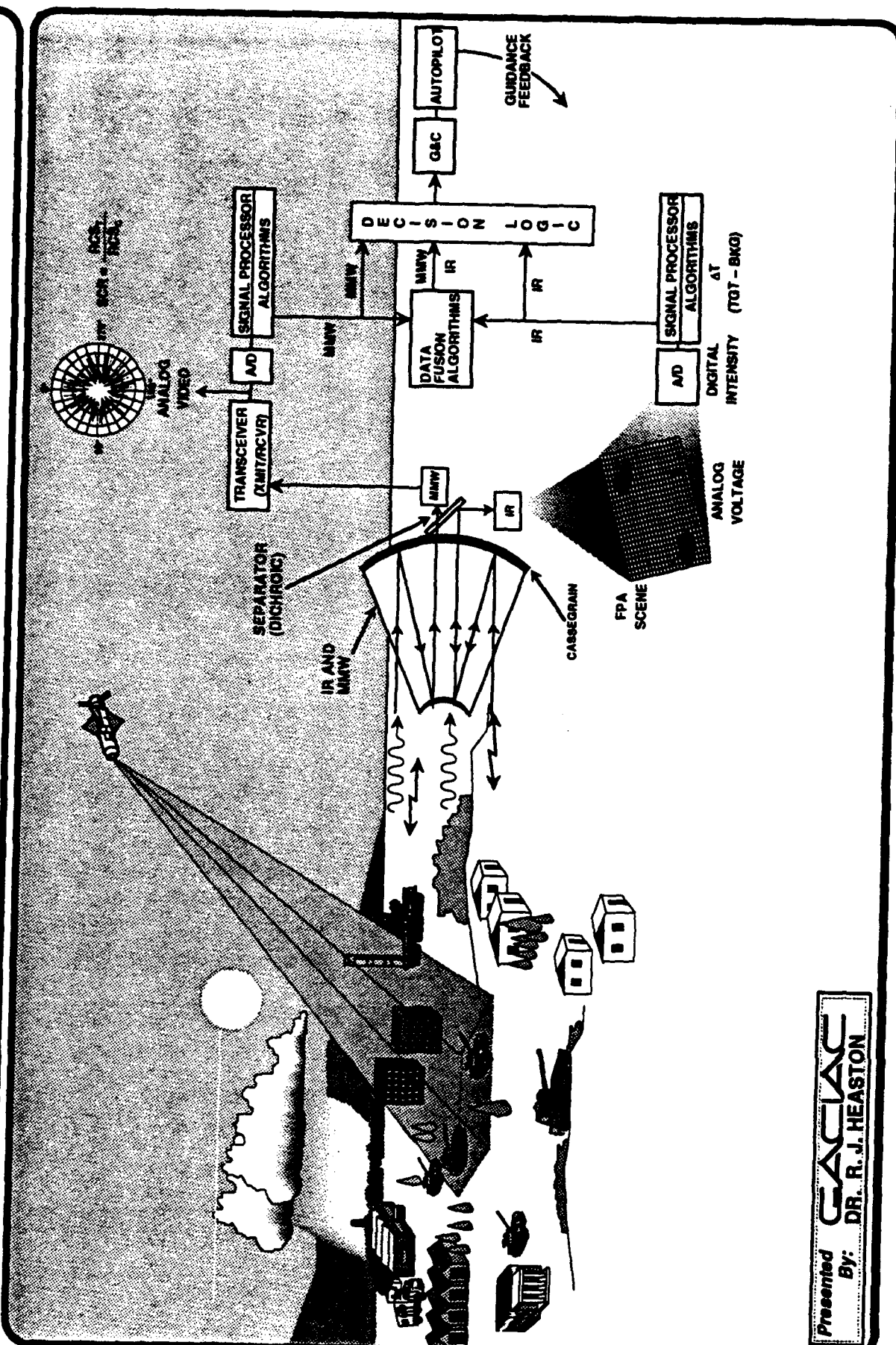
# CAPABILITY ASSESSMENT METHODOLOGY



- (1) PROBABILITY OF DETECTION OF GROUND TRUTHED TARGETS & PROBABILITY OF FALSE ALARM FOR CMs/CLUTTER
- (2) PROBABILITY OF CORRECT CLASSIFICATION
- (3) PROBABILITY OF CORRECT TARGET ORIENTATION - WITHIN DEFINED TOLERANCE (AS APPLICABLE)



# DUAL MODE REPRESENTATION



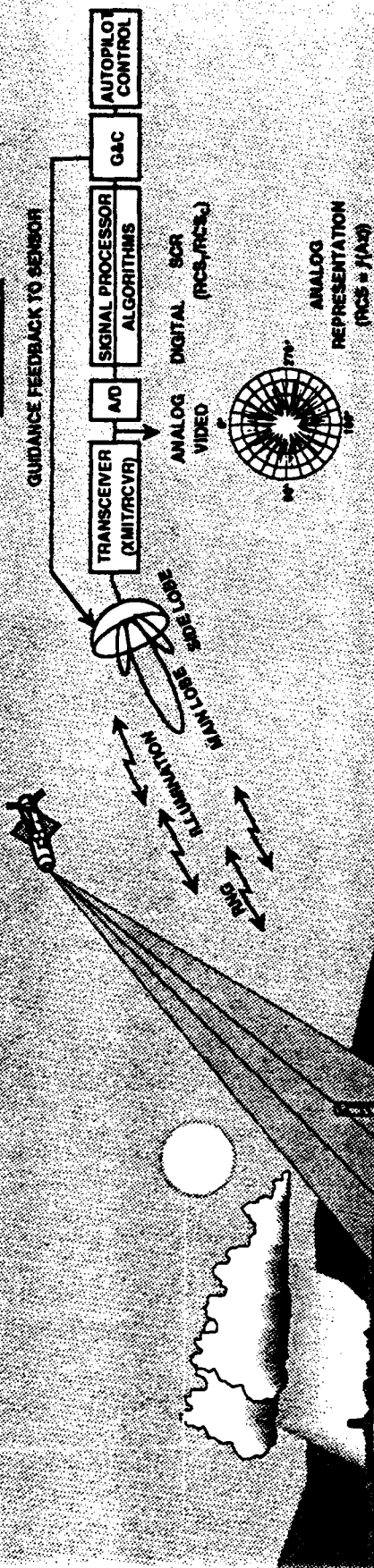
Presented By: **GACIAC**  
DR. R. J. HEASTON

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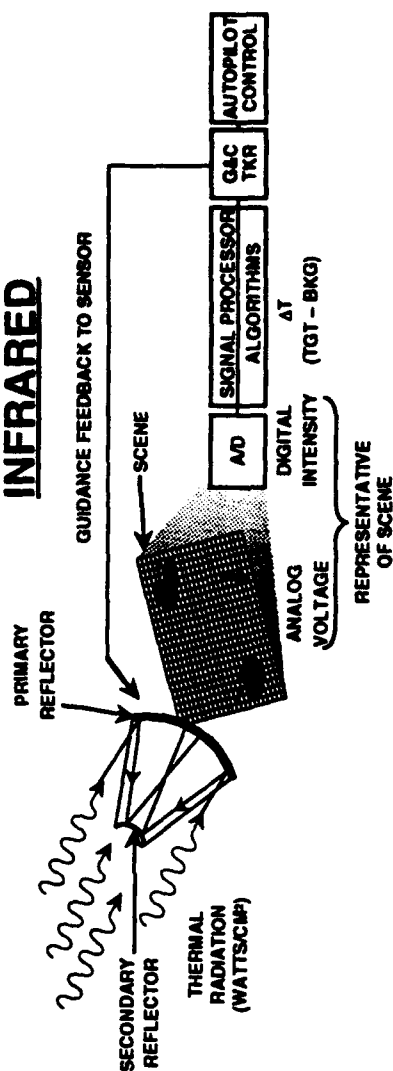
GACIAC NO. 5-7

# RADAR AND INFRARED REPRESENTATION

## RADAR



## INFRARED

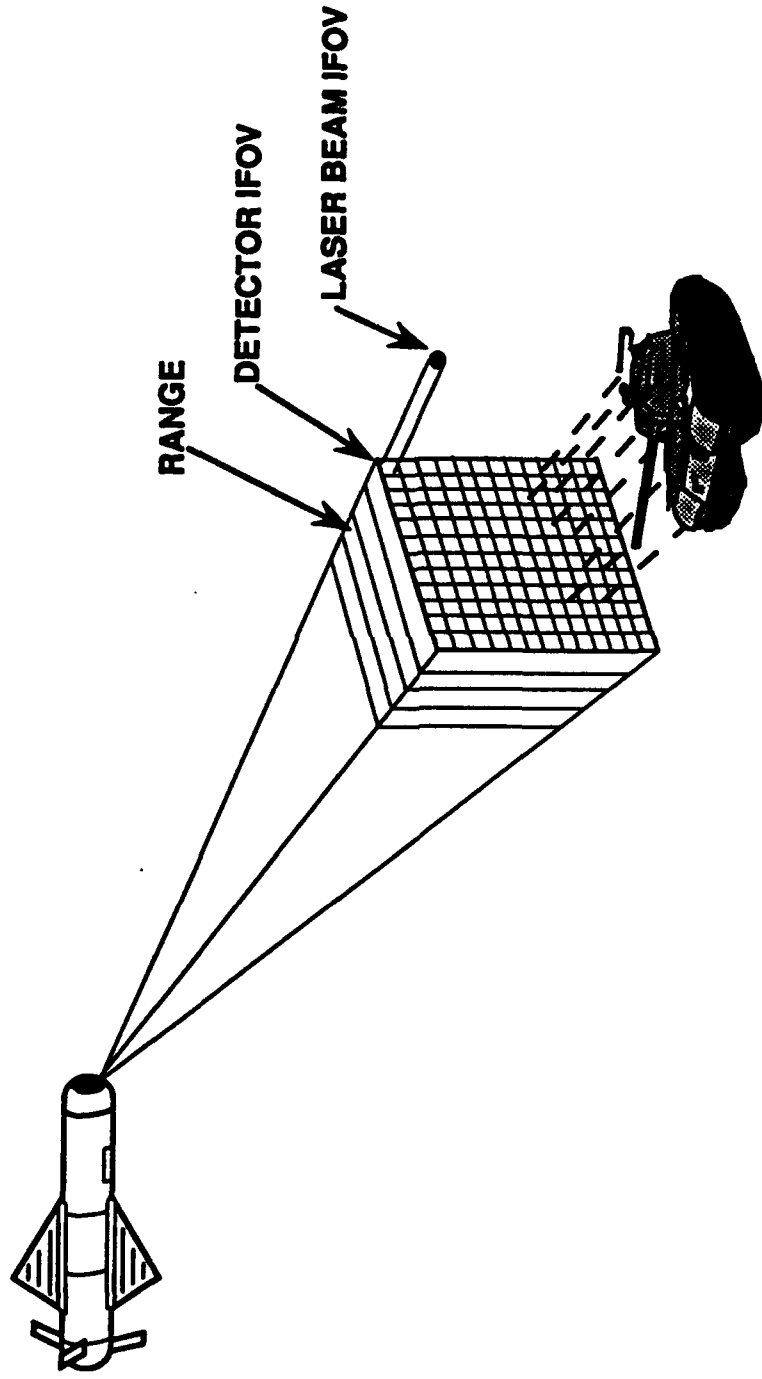


Presented By: **DR. R. J. HEASTON**

28993-08/022dw

QACIAC NO. 5-8

# LADAR TARGET SIGNATURE



- LADAR SYSTEMATICALLY MEASURES RANGE TO PIXELS ON REFLECTING SURFACES
- LADAR PROVIDES HIGH RESOLUTION IN RANGE AND ANGLE (AZIMUTH AND ELEVATION)
- RESULT IS HIGH RESOLUTION 3-4 IMAGERY

# ACOUSTIC RESEARCH PROJECTS

## EARLY PROGRAMS

ACOUSTIC  
SIGNATURE  
QUALITY  
METRICS  
ARL

ACOUSTIC  
DATABASE  
FEASIBILITY  
STUDY  
ARL

FOXFIRE  
31  
ARL

ACOUSTIC  
JAMMER  
SLAD

ANTI-HELO MINE  
CM INVESTIGATION  
ARPA

JOINT  
ACOUSTIC  
PROPAGATION  
EXPERIMENT  
ARL, OTHERS

## CURRENT PROGRAMS

REMOTE NETTED ACOUSTIC  
DETECTION SYSTEM  
(RNADS)

CONUS  
TEST

OCOONUS  
TEST

ACOUSIC  
TARGET  
TRACKER

AUTOMATIC  
TARGET  
CLASSIFIER

ARL

WAM  
ALGORITHM  
EVALUATION  
WES

WAM  
MODEL  
V & V  
ARDEC

ACOUSTIC  
DECOY  
ASSESSMENT  
BRDEC

UNATTENDED  
GROUND SENSOR  
SIMULATION  
SANDIA

BATTLEFIELD  
ACOUSTICS  
SIMULATION  
SYSTEM  
ARL

INTELLIGENT  
MINEFIELD  
ARDEC

BRILLIANT  
ANTI - ARMOR  
SUBMUNITION  
BAT - PM

## MODELING

BEYOND LOS  
LONG - RANGE  
ACOUSTIC  
SURVEILLANCE &  
TRACKING

## FUTURE DIRECTIONS

• CIVILIAN NOISE  
MONITORING

• ATC DEMO

• COUNTER - DRUG

• BATTLEFIELD  
SURVEILLANCE

• PERIMETER  
SECURITY

• MINE CM

Programs are managed by the  
Acoustic Research Division

## **MULTIPLE SENSOR SUITES**

- **SEEKERS REQUIRE AN ARCHITECTURE TO EMPLOY THE OUTPUTS OF MORE THAN ONE SENSOR**
- **SEQUENTIAL OPERATION (HANDOVER) -- TAKES ADVANTAGE OF COMPLEMENTARY SENSOR CHARACTERISTICS; i.e., ACQUISITION RANGE VERSUS TRACKING ACCURACY**
- **SIMULTANEOUS OPERATION -- PROVIDE ADDITIONAL MARGIN OF PERFORMANCE ENHANCEMENT TO ACQUIRE AND TRACK CHALLENGING TARGETS; i.e.. LOW OBSERVABLES, HIGH VALUE AND COLD STATIONARY TARGETS**

## **SUMMARY**

### **PRODUCTS / VALUE**

- **GACIAC HAS CONSIDERABLE EXPERIENCE IN STATE-OF-THE-ART SENSOR/SEEKER ANALYSIS**
  - VARIOUS SENSOR/SEEKER TECHNOLOGIES
  - SIGNAL PROCESSING TECHNIQUES/ALGORITHMS
  - TEST & EVALUATION
  - TARGET SIGNATURES
- **GACIAC PROVIDES TECHNOLOGY ASSESSMENTS, TECHNICAL REPORTS, SOTA REVIEWS, ETC.**
- **GACIAC SUPPORTS A VARIETY OF DoD CUSTOMERS AT VARIOUS LEVELS**

# **SENSORS AND ELECTRONIC DEVICES: MULTISPECTRAL DETECTION**

**Presented by:**

**Rodney C. Anderson  
Director**

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**Approved for Public Release: Distribution Unlimited**



# **MULTISPECTRAL DETECTION: CONTEXT**

- CAMOUFLAGED AND CONCEALED TARGETS ARE OFTEN DIFFICULT TO DETECT USING CONVENTIONAL SENSOR DUE TO LOW CONTRAST AND HIGH THERMAL NOISE
- REQUIREMENTS FOR RAPID SEARCH AND DETECTION HAVE INCREASED (E.G., SEARCHING FOR SCUDS DURING THE GULF WAR)
- BACKGROUND AND TARGETS HAVE SPECTRAL FEATURES WHICH ARE SUBJECT TO EXPLOITATION TO ENHANCE DETECTION
- SEVERAL MISSIONS SUPPORTED:
  - Tactical Sea-based Air Forces
    - o Reconnaissance
    - o Deep strike
  - Naval Surface
    - o Naval shore bombardment
    - o Amphibious forces support

# **MULTISPECTRAL DETECTION TASK**

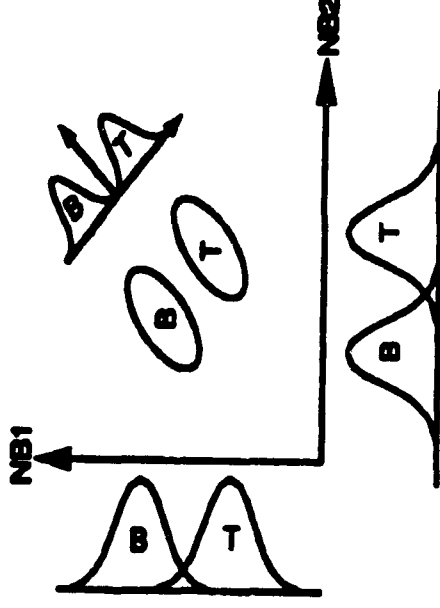
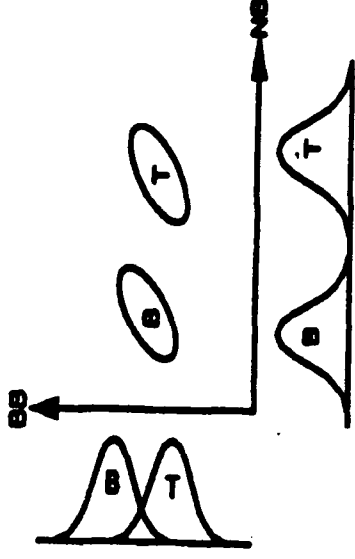
- **IMPLEMENTATION OF SENSOR KEY TECHNOLOGY (PASSIVE ELECTRO-OPTICAL SENSING)**
- **TASK FOCUS**
  - Evaluate fundamental phenomenology and mathematical basis of multispectral sensing
  - Sponsor: Naval Research Laboratory
  - Products consisted of reports, briefings, data, and analysis

# METHODOLOGY

- ISSUES
  - Evaluate spectral properties
    - Backgrounds
    - Targets (paints)
  - Develop foundation for MLR multispectral detection
- APPROACH
  - Use existing data for initial evaluation
    - IR Handbook, Handbook of Spectral Data...
    - Spectral reflectance data
    - Measured data (Fourier Transform spectroscopy)
  - Extend existing models to multispectral domain
    - "Flat plate" radiance model
    - Vegetative canopy model
  - Use temperature projection to remove thermal noise

# TASK SUMMARY

- DATA EVALUATION
  - Spectral features exist in the thermal infrared
  - Identified fundamental physical processes that contribute to spectral structure
- DEVELOPED BASIS OF TEMPERATURE PROJECTION ON GENERALIZED MAXIMUM LIKELIHOOD RATIO TEST



# TASK RESULTS

- MULTISPECTRAL TECHNIQUES CAN THEORETICALLY INCREASE SIGNAL TO CLUTTER GAIN BY ORDERS OF MAGNITUDE
- ADDITIONAL HIGH RESOLUTION DATA FOR SPECIFIC SCENARIOS ARE REQUIRED
- REQUIREMENTS FOR ADDITIONAL DATA ACQUISITIONS DEVELOPED

## **CONSEQUENCES**

- **MULTISPECTRAL SENSING MAY YIELD GREATLY INCREASED DETECTION PERFORMANCE UNDER SOME CIRCUMSTANCES**
- **SMALLER (CHEAPER) MULTISPECTRAL SENSOR POSSIBLE SUBSTITUTE FOR EQUIVALENT NON-SPECTRAL SENSOR**
- **MULTISPECTRAL HAS POTENTIAL TO DETECT TARGET NOT DETECTABLE BY ANY OTHER MEANS**

# **TASK RELEVANCE**

- **MULTISPECTRAL TECHNOLOGY RELEVANT TO:**
  - Environmental awareness
  - Trafficability analysis
  - Geologic exploration
  - Agricultural surveys
- **TASK METHODOLOGY RELEVANT TO:**
  - General automated passive remote sensing problem
  - Automated machine vision
  - Airborne/ ground based passive IR sensing

**FAILURE MODE/MECHANISM DISTRIBUTIONS**

**(DoD MISSION/FUNCTION: MAINTENANCE,  
READINESS AND LOGISTICS)**

**Prepared By**

**Preston R. MacDiarmid  
Director  
Reliability Analysis Center  
201 Mill Street  
Rome, NY 13440-6916**

**Approved for Public Release: Distribution Unlimited**



# **RAC PRODUCT STRATEGY**

- **TARGET MANAGERS**

- **Awareness**
- **Impact on programs**
- **Basics**
  - o **Terminology**
  - o **Tasks**
  - o **Subtasks**
- .
- .
- .

- **TARGET DESIGNERS**

- **Impact of new technologies**
- **Design practices/guidelines**
- **Ability to trade-off alternatives**

- **TARGET R/M/Q PRACTITIONERS**

- **Procedural guides**
- **Data to support analyses**
- **Quick guides/automated tools**

# **PRODUCT RELEVANCE**

- **DOD MISSION/FUNCTION: MAINTENANCE, READINESS AND LOGISTICS**
- **PRODUCT FOCUS**
  - **How components fail**
  - **Frequencies of different modes/mechanisms**
- **PRODUCT IMPACT**
  - **Enables evaluation of failure consequences**
    - o **Availability**
    - o **Maintenance**
    - o **Safety**

<b>PART DESC.</b>	<b>FAILURE MODE/MECH</b>	<b>NORM DIST.</b>
-----------------------	------------------------------	-----------------------

---

**Resistor, Fixed (Summary)**

<b>Opened</b>	<b>51.0%</b>
<b>Drift</b>	<b>29.1%</b>
<b>Change in Resistance</b>	<b>7.0%</b>
<b>Broken</b>	<b>5.4%</b>
<b>Shorted</b>	<b>4.0%</b>
<b>Mechanical Failure</b>	<b>3.5%</b>

---



PART DESC.	FAILURE MODE/MECH	NORM DIST.	FAIL DIST.	DATA SOURCE(S)/DETAILS
---------------	----------------------	---------------	---------------	---------------------------

**Resistor,Fixed,Wire Wound,Precision**

**Sources: 3**

Opened	50.5%	50.5%	Open-Bad Welds (25016-000, NR) High Z (24991-000, 71.0%) Open (24994-000, 30.0%)
Drift	32.5%	32.5%	Drift (24994-000, 65.0%)
Shorted	17.0%	17.0%	Low Z (24991-000, 29.0%) Short (24994-000, 5.0%)
Other	----	0.0%	
Change in Resistance		NR	Change in Resistance-Unstable Wire (25016-000, NR), Change in Resistance-Poor Processing (25016-000, NR), Change in Resist-Partial Short From Bad Wire Insul (25016-000, NR)

# **CURRENT RAC PRODUCTS**

<b>DATA PUBLICATIONS</b>	<b>6 *</b>
<b>APPLICATION GUIDES</b>	<b>11</b>
<b>COMPONENT PUBLICATIONS</b>	<b>7</b>
<b>SPECIALIZED SERIES:</b>	
-- <b>Concurrent Engineering</b>	<b>5</b>
-- <b>Reliable Applications of Components</b>	<b>3</b>
-- <b>Total Quality Management Series</b>	<b>3</b>
<b>SOFTWARE/DATABASES</b>	<b><u>7</u></b>
	<b>42</b>

**TIME STRESS MEASUREMENT DEVICE (TSMD)**

**(DoD KEY TECHNOLOGY: SENSORS AND  
ELECTRONIC DEVICES)**

**Prepared By**

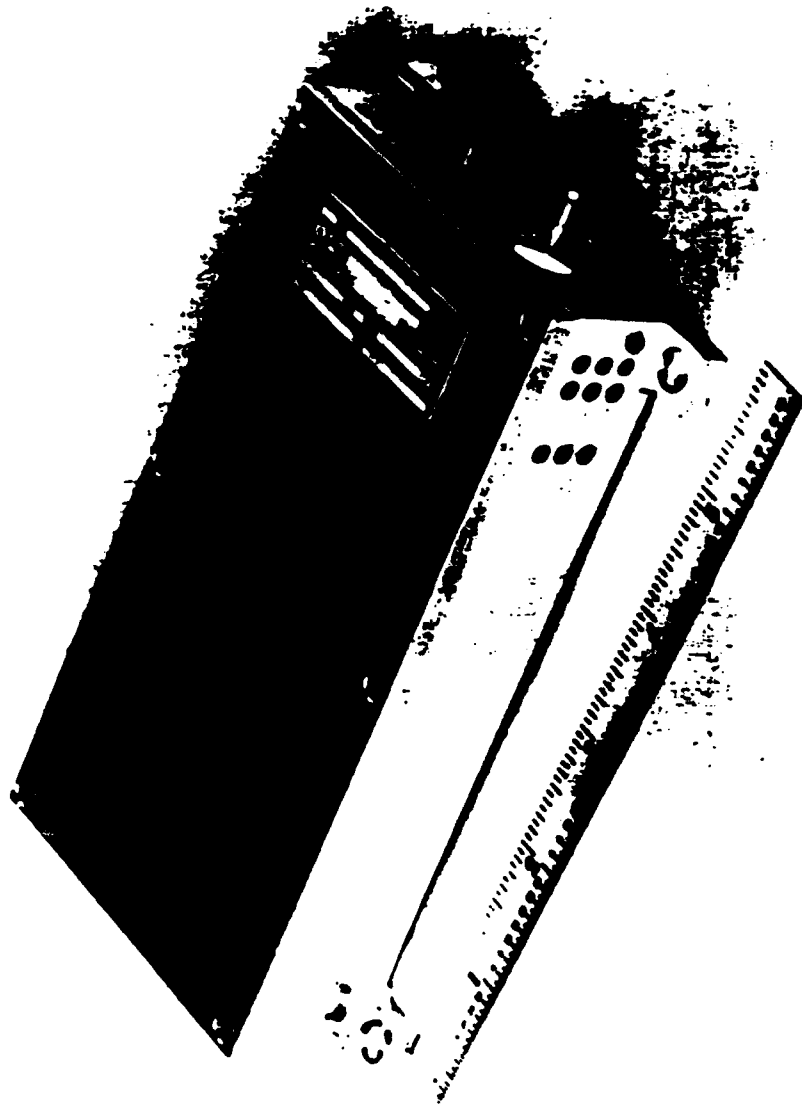
**Preston R. MacDiarmid  
Director  
Reliability Analysis Center  
201 Mill Street  
Rome, NY 13440-6916**

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# **CAPABILITY RELEVANCE**

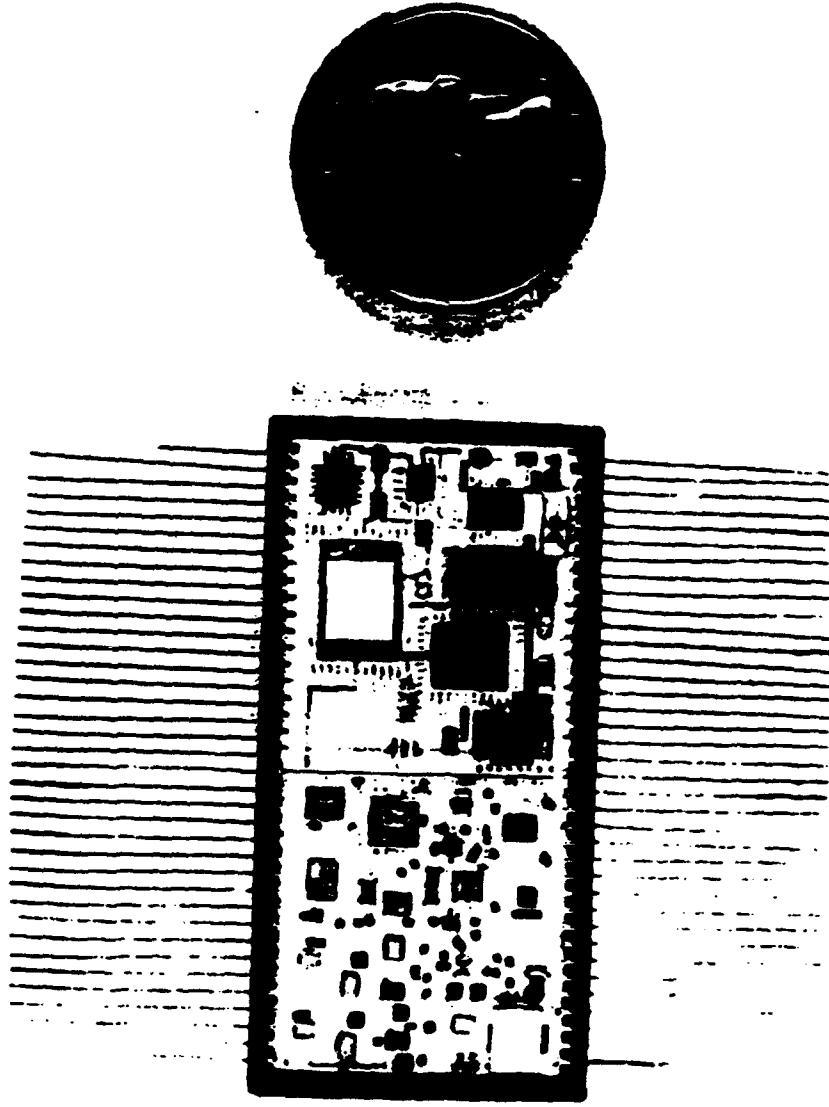
- **DOD KEY TECHNOLOGY: SENSORS AND ELECTRONIC DEVICES**
- **CAPABILITY RELEVANCE**
  - **Electronic device improvements make environmental characterization cost effective**
- **CAPABILITY IMPACT**
  - **More reliable system by**
  - o **Effective characterization of design environments**
  - o **Identification of environmental stresses causing field problems**

# TSMD MODULE

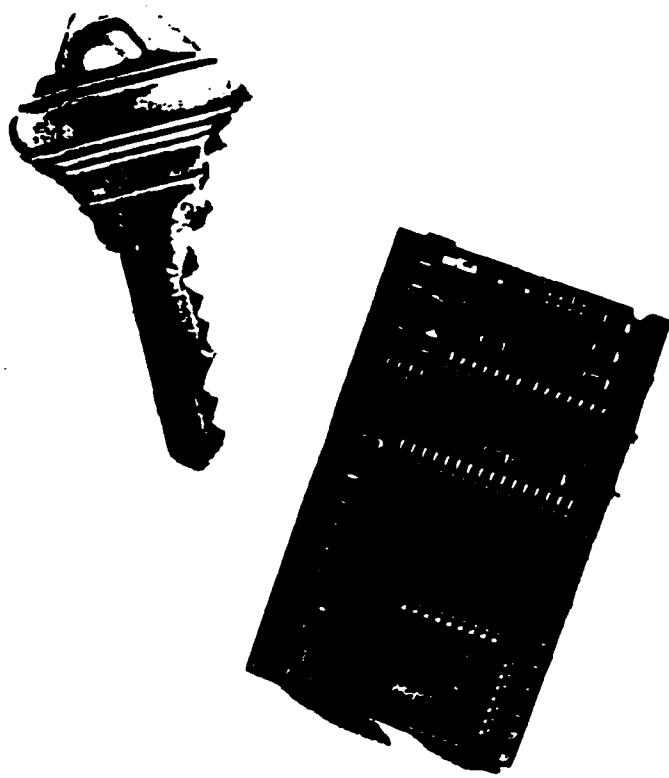




# MICRO TSMD



**COMMERCIAL TSMD DEVICE**



**ENVIRONMENTAL MEASUREMENT DEVICE  
(As of Jun 8 1993)**

**MANUFACTURER:** Onset Computer Corp.  
**MODEL NUMBER:**  
**MODEL NAME:** Hobo-Temp (RAC ID 33)  
**COST:** \$99.0 - \$167.0  
**TYPE:** ALONE  
**SIZE: (L-W-H):** 2.0 - 1.0 - 1.0 Inches  
**WEIGHT:** oz  
**POWER REQ:** One-cell battery  
**POWER LIFE:** Up to 4 years  
**NO. READINGS:** 1800  
**SAMPLE RATES:** MIN. 0.0000580 MAX. 2.0000000 (In cy/sec)  
**MEMORY:** Non-volatile EEPROM  
**NO. I/O LINES:** DIGITAL I/O: 0/1 ANALOG I/O: 1/0  
**INTERFACES:** RS232 serial Interface  
**EVENT TAGGING:** Time stamp Date stamp  
**SENSORS:** Internal Temperature

**MFR. SUGGESTED APPLICATIONS:**

## **RAC TSMD ACTIVITIES**

- **RAC PUBLICATION: ENVIRONMENTAL CHARACTERIZATION  
DEVICE DATABASE**
  - **Identifies available device technology**
    - o **Measurement**
    - o **Recording**
    - o **Parameters, limits, etc.**
- **RAC SERVICE: SELECT/APPLY TECHNOLOGY FOR SPECIFIC  
PROGRAM**
- **RAC DATABASES: RETAIN DATA COLLECTED TO PREVENT  
DUPLICATION**

## ENVIRONMENTAL EFFECTS

**BIO TECHNOLOGY: A SURVEY OF SEVEN  
TECHNOLOGIES TO IDENTIFY CLOSTRIDIUM  
BOTULINUM AND BACILLUS ANTHRACIS**

**Prepared by**

**Dr. Salvatore Bosco, Dr. Leo Laughlin, Milton Miles and James McNeely  
CBIAC  
Chemical Biological Information Analysis Center  
Battelle  
2113 Emmorton Park Road  
Edgewood, MD 21040**

**Approved for Public Release: Distribution Unlimited**

## **CONTEXT**

- **BIOLOGICAL WARFARE CONVENTION TECHNICAL DISCUSSIONS**
- **IDENTIFY TECHNICAL ISSUES ASSOCIATED WITH DEVELOPMENT OF VERIFICATION INITIATIVES**

**Prepared by: Salvatore Bosco, et al**

**CBIAC - 2**



## **BIO TECHNOLOGY TASK**

- **WHY**
  - **Technical Exchanges**
    - International Assertions on BWC Verifiability
    - Claims of Equipment Capabilities
    - Provide Common Denominator for Comparison of Technical Specifications
    - Need to Define Technical Terminology
    - Capture Current Information on Rapid-Paced Technological Advances
    - Provide Technical Information to Negotiators who have Little Technical Background
    - Technical and Policy Experts use same "Sheet of Music"
    - Need to Address Real-World Problems
      - False Positive (vs False Negatives)
      - Masking Issues/Interferences
- **WHO**
  - **Office of the Secretary of Defense (OSD/ISP/MN)**
- **WHAT**
  - **Technical Review of Leading Edge Technologies for Identification of Botulinum and Anthrax**



## **IAC METHODOLOGY**

- **SCOPE TO WORKABLE SET OF TECHNOLOGIES FOR PROOF OF CONCEPT**
- **WORLD-WIDE SEARCH FOR RELEVANT LITERATURE**
- **CULL FOR QUANTITATIVE INFORMATION ON SPECIES IDENTIFICATION**
- **MATRIX TECHNOLOGIES VS AGENTS**
- **CREATE ROLL-UP SECTIONS WITH INCREASING DEGREES OF TECHNICAL DETAIL**
- **THOROUGHLY REFERENCED**
- **EXPERT REVIEW AND EVALUATION OF TECHNICAL/MEDICAL LITERATURE**

## **SUMMARY OF DATA**

- **OVERVIEW OF CUTTING-EDGE TECHNOLOGIES**
- **REVIEW OF APPLICABILITY TO SPECIFIC IDENTIFICATION**
- **EXPERIENCED SCIENTISTS FOR EVALUATION**
- **MATRIX PRESENTATION ALLOWS FOR EASY EXTENSION TO OTHER DISEASE-CAUSING ORGANISMS OF INTEREST**

## **RESULTS OF DATA ANALYSIS**

- **BW TECHNOLOGY DOCUMENT PROVIDED U.S. NEGOTIATORS WITH DATA TO EFFECTIVELY RESPOND TO PROPOSALS FOR BWC VERIFICATION REGIMES**

**Prepared by: Salvatore Bosco, et al**

**CBIAC - 6**

## **CONSEQUENCES**

- **DOCUMENT PROVIDED TO U.S. BWC TECHNICAL REPRESENTATIVES**
- **EXTRACTS OF DOCUMENT DISTRIBUTED TO INTERNATIONAL DELEGATES**

## **RELEVANCE TO OTHER USERS**

- **WORLD HEALTH ORGANIZATION**
- **INDUSTRY**
- **NATIONAL INSTITUTE OF HEALTH**
- **CENTER FOR DISEASE CONTROL**
- **ACADEMIA**

# **DESIGN AND ANALYSIS OF A LOW SPEED DRAG PLOW FOR DEEP SNOW**

**Presented by**

**Peter D. Smallidge  
CECRL-ORTA**

**Authored by**

**Michael R. Walsh, CECRL-TE, and Paul W. Richmond, CECRL-EA  
U.S. Army Cold Regions Research and Engineering Laboratory  
72 Lyme Road  
Hanover, New Hampshire 03755-1290**

**Approved for Public Release: Distribution Unlimited**

# CONTEXT

- **DOD MILITARY MISSIONS / FUNCTIONS**
  - **Ground Forces**
    - » **Mobility, Logistics, and Supply**
      - **Force projection**
      - **Low intensity conflict**

Prepared by: P. D. Smallidge

IAC PLOW-1

# **IAC TASK / BASIC INFORMATION PRODUCT**

- **USER PROBLEM / REQUIREMENT**
  - Winter logistics operations for Army field units in Alaska hampered by deep snow
  - Existing equipment:
    - » 2-1/2 ton truck
    - » HMMWV
    - » SUSV
  - Develop snow clearing device for support off-road winter exercises with wheeled vehicles
- **IAC PRODUCT FOCUS**
  - Review snow handling options
  - Evaluate snow / terrain conditions
  - Literature and patent search on plow technology



# **SUMMARY OF FINDINGS**

- **SNOW HANDLING OPTIONS**
  - Compaction
  - Blowing / throwing
  - Melting
  - Plowing
- **SNOW / TERRAIN CHARACTERISTICS**
  - Low density snow, 1 meter deep
  - Terrain is uneven with brush, hummocks, and fallen trees
- **PLOW TECHNOLOGY**
  - V-Shaped drag plow
  - SUSV adaptable to plow technology

Prepared by: P. D. Smallidge

IAC PLOW-3

# **CONSEQUENCES**

- **LABORATORY AND MODEL STUDIES TO DEVELOP PLOW AND TOW MECHANISM DESIGNS**
- **FIELD EVALUATION OF HALF AND FULL-SCALE MODELS**
  - Snow depths to 1 meter
  - Within SUSV operating parameters
- **PATENTS ON PLOW AND TOWING MECHANISMS**

# **RELEVANCE TO OTHER USERS**

- **TOWED SLEDS**
  - SUSV in Alaska
  - Challenger in Antarctica
  - Soft ground / marshes
- **FARMING APPLICATIONS**

Prepared by: P. D. Smalldge

IAC FLOW-5



# **OBSERVATIONS OF ACOUSTIC SURFACE WAVES PROPAGATING ABOVE A SNOW COVER**

**Presented by**

**Peter D. Smallidge  
CECRL-ORTA**

**Authored by**

**Dr. Donald G. Albert, CECRL-RG  
U.S. Army Cold Regions Research and Engineering Laboratory  
72 Lyme Road  
Hanover, New Hampshire 03755-1290**

**Approved for Public Release: Distribution Unlimited**

# CONTEXT

- **DOD KEY TECHNOLOGY**
  - Environmental Effects: The automated generation of near-real-time environmental tactical decision aids to determine the adverse effects of dynamic battlefield environments on characterization and modeling of military requirement and operations.
- **DOD SCIENCE AND TECHNOLOGY THRUST**
  - Precision Strike: Against critical mobile and fixed targets in all-weather; day/night; and foliage- and camouflage-resistant environments.
- **DOD CRITICAL TECHNOLOGY**
  - Signal and Image Processing
    - » Combination of computer architecture, algorithms, and microelectronic signal processing devices for near real-time automation of detection, classification, and tracking of targets.
  - Weapon System Environment
    - » A detailed understanding of the natural environment and its influence on weapons system design and performance.

# **IAC TASK / BASIC INFORMATION PRODUCT**

- **TECHNICAL ISSUE**
  - Seismic and acoustic waves are useful for non-line-of-sight surveillance and targeting , but are greatly affected by ground conditions, especially in cold regions (snow, ice, frozen ground).
- **IAC PRODUCT FOCUS**
  - Literature search on acoustic coupling processes
  - Survey of acoustic modeling concepts for porous media
  - Analysis of relevant approaches to simulate effects of snow cover
  - Customers: U.S. Army Engineer School; U.S. Army Armament RD&E Center

Prepared by: P. D. Smallidge

IAC-ACOU-2

# **SUMMARY OF FINDINGS**

- **RESEARCH OBJECTIVE**
  - Gain an understanding of winter environmental effects on seismic and acoustic waves.
  - Develop predictive capabilities applicable to NLOS surveillance and targeting systems.
- **RESEARCH APPROACH**
  - Combine experimental, theoretical and computational approaches to understand and predict winter impact on seismic and acoustic waves.
- **SURVEY FINDINGS**
  - Little understanding of:
    - » Dominant propagation modes
    - » Critical properties (wave speed, attenuation rate)
    - » Controlling environmental parameters
  - Biot's Theory offers analysis approach

Prepared by: P. D. Smallidge

IAC-ACOU-3

# CONSEQUENCES

- **RESULTS**

- High attenuation rates for atmospheric acoustic waves above snow covers.
- Theoretical definition of dominant energy propagation modes in porous media.
- Permeability is controlling factor.
- Practical model developed to predict signal characteristics for varying environmental conditions.

- **IMPACT**

- Ability to predict ground sensor performance for a wide range of conditions.
- Applicable to future NLOS sensor development and current systems such as Wide Area Mine.



# **RELEVANCE TO OTHER USERS**

- **PHYSICAL SECURITY SYSTEMS**
  - Sensor performance, design, and evaluation
- **ENVIRONMENTAL QUALITY**
  - Noise abatement predictions

Prepared by: P. D. Smallidge

IAC-ACOU-5

# **SHIP SUPERSTRUCTURE ICING**

## **Presented by**

**Peter D. Smallidge  
CECRL-ORTA**

## **Authored by**

**Dr. Charles C. Ryerson, CECRL-RS, and LCDR Paul D. Longo, USN  
U.S. Army Cold Regions Research and Engineering Laboratory  
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**Approved for Public Release: Distribution Unlimited**

# CONTEXT

- **DOD KEY TECHNOLOGY**
  - Environmental Effects: The automated generation of near-real-time environmental tactical decision aids to determine the adverse effects of dynamic battlefield environments on characterization and modeling of military requirement and operations.
- **DOD SCIENCE AND TECHNOLOGY THRUST**
  - Sea control and undersea superiority. The need to maintain an overseas presence and operate in littoral zones in a broad range of environmental conditions.
- **DOD CRITICAL TECHNOLOGY**
  - Simulation and Modeling

Prepared by: P. D. Smallidge

IAC-ICE-1

# **IAC TASK / BASIC INFORMATION PRODUCT**

- **RESEARCH OBJECTIVE:**
  - Allow vessels to avoid hazardous conditions or to minimize the accretion of ice by predicting:
    - » Environmental conditions under which icing may occur
    - » Icing rates
    - » Predominant icing locations on the vessel
- **IAC PRODUCT FOCUS**
  - Survey and analyze existing ship spray icing models
  - Evaluate available data on ship icing
  - Customer: U.S. Navy David W. Taylor Naval Ship Research Center

# **SUMMARY OF DATA**

- **MODELS**
  - Most are empirical and based on trawler data
  - Do not consider the physical processes they simulate
  - Cannot be transferred to larger ships
  - University of Alberta numerical ship icing model
- **DATA**
  - Lack of data on large ship icing

Prepared by: P. D. Smallidge

IAC-ICE-3

# **CONSEQUENCES**

- **RESEARCH EFFORTS**
  - Calibration and validation of Alberta model
  - Development and evaluation of spray and ice measurement equipment
  - Research cruise USCGC Midget
- **RESULTS**
  - Good video and weather data
  - Partial success on automated spray and icing measurements
  - Sufficient data to verify Alberta model for Navy

# RELEVANCE TO OTHER USERS

- **OTHER DIRECT APPLICATIONS**
  - Shoreline / coastal facilities
    - » Logistics over the shore
    - » Coastal radar / communications facilities
    - » Offshore oil platforms
  - Commercial fishing and shipping
- **SPINOFFS**
  - Shipboard instrumentation lessons learned

Prepared by: P. D. Smallidge

IAC-ICE-5

# **SMART WEAPONS OPERABILITY ENHANCEMENT (SWOE) PROGRAM**

**Presented by**

**Peter D. Smallidge  
CECRL-ORTA**

**Program Manager**

**Dr. James P. Welsh, CECRL-SW  
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**Approved for Public Release: Distribution Unlimited**



# CONTEXT

- **DOD SCIENCE AND TECHNOLOGY THRUST**
  - Synthetic Environments: Provide computer- and electronics-based technology for development, testing, training and readiness to synthesize factory-to-battlefield environments.
  - Precision Strike: Against critical mobile and fixed targets in all-weather; day/night; and foliage- and camouflage-resistant environments.
- **DOD KEY TECHNOLOGY**
  - Environmental Effects: The automated generation of near-real-time environmental tactical decision aids to determine the adverse effects of dynamic battlefield environments on characterization and modeling of military requirement and operations.
- **DOD CRITICAL TECHNOLOGY**
  - Simulation and Modeling
  - Weapon System Environment

# **IAC TASK / BASIC INFORMATION PRODUCT**

- **ARMY TECHNOLOGY BASE MASTER PLAN**
  - Science and Technology Objective, VI.C.5., Smart Weapons Operability Enhancement
    - » Develop analytical IR and MMW models to robustly simulate geographical and time/weather driven character of environmental scenes.
    - » Develop validated multi-sensor scene generation capability for quantitative consideration of environmental conditions in the design, test and evaluation of smart weapon and ATR devices.
- **IAC PRODUCT FOCUS**
  - Survey and analyze environmental science technologies to support development of an integrated, physics based, scene generation process.
    - » Measurement and Information Bases
    - » Analytical Models
    - » Scene Rendering Software
  - Customer:
    - » OSD Joint Test & Evaluation Program
    - » U.S. Army Smart Weapons Management Office
    - » Individual Emerging Systems

# **SELECTED PRODUCTS**

## **SWOE PROGRAM**

- 88-1, Program Implementation Plan, USACRREL, Jan 89
- 90-1, One-Dimensional Temperature Modeling Techniques, EG&G Energy Measurements / SPARTA / NASA Goddard Space Flight Center, Aug 90
- 90-8, Representative Weather Data Sets for Hunfeld, Federal Republic of Germany, USAASL, Jul 90
- 90-9, Comparison of Climatologies of Selected SWOE Test Sites, USAASL, Aug 90
- 90-15, Three Dimensional Modelling of Background Scenes at Millimeter Waves, MIT Research Lab. of Electronics, Dec 90
- 92-1, Information Base Procedures for Generation of Synthetic Thermal Scenes, USAEWES, Feb 92
- 92-2, Review of Environmental Research Specific to SWOE for the Battlefield Environment, USACRREL/USATEC/ USAEWES, Jun 92
- 92-6, Data Analysis for Bark and Leaf Reflectance Measurements, Spectral Sciences, Inc./Phillips Lab., Jun 92
- 93-1, A Review of Millimeter Wave Modeling, USACRREL, Mar 93

# **IAC METHODOLOGY**

- **DATA BASES**
  - Survey environmental data from military test sites
  - Analyze for
    - » Validity
    - » Range of relevant conditions
- **MODELS**
  - Initial survey of sensor models relevant to smart weapons - IR and MMW
  - Survey and compilation of IR models
  - Workshop to establish / synthesize MMW techniques
- **SIMULATION**
  - Survey government and commercial technologies
  - Evaluate based on smart weapon system drivers / parameters

# **SUMMARY OF FINDINGS**

- **PERFORMANCE OF SMART WEAPONS SYSTEMS HAS BEEN UNPREDICTABLE AND UNRELIABLE FOR EXTRAPOLATION TO THE GLOBAL RANGE OF BATTLEFIELD CONDITIONS.**

- Effects of the environment are treated in generic rather than specific ways.
- There are no environmental criteria for development or testing. The environment is not defined in terms relevant to the performance of smart weapons.
- Environment performance criteria are not keyed to the specific regions within which that system must operate.

- **OPTIONS TO SOLVE THE PROBLEM**

- Real imagery data
- Hybrid imagery
- Synthetic imagery

# CONSEQUENCES

- **RECOMMENDED APPROACH:**
  - Validated scene generation process
    - » Integrated physics based models
    - » Terrain and weather data base driver
    - » Workstation environment
  - Compatibility with Distributed Interactive Simulation
- **RESULT:**
  - Smart Weapon Operability Enhancement Joint Test & Evaluation (SWOE JT&E) program initiated in 1992, \$15.2M funding, 3 years
  - Impact: Early consideration of environment in design, optimization of testing, extrapolation of test results

# **RELEVANCE TO OTHER USERS**

- **PHYSICAL SECURITY SYSTEMS**
  - Sensor performance design and evaluation
  - Criteria for logic design to reduce false alarms
- **REMOTE SENSING**
  - Mission planning
  - Image analysis criteria
  - New sensor design / evaluation

Prepared by: P. D. Smallidge

IAC SWOE -7

# **WATERFOWL MORTALITY IN EAGLE RIVER FLATS, ALASKA**

**Presented by**

**Peter D. Smallidge  
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**Authored by**

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# CONTEXT

- **DOD MILITARY MISSIONS / FUNCTIONS**
  - Training
    - » General military training - artillery
- **ARMY MODERNIZATION STRATEGY**
  - Optimize readiness and training
    - » Maximize existing soldier skills

# **IAC TASK / BASIC INFORMATION PRODUCT**

- **BACKGROUND - 1990**
  - Eagle River Flats (ERF) 6th ID(L) Artillery Training Area closed due to long-term (10 years) waterfowl mortality
  - Cause of waterfowl mortality unconfirmed
  - 6th ID(L) forced to seek alternative training sites
- **IAC PRODUCT FOCUS**
  - Literature search on causes of waterfowl mortality
  - Review of previous studies
  - Survey of data analysis techniques

Prepared by: P. D. Smallidge

IAC ERF-2

# **SUMMARY OF FINDINGS**

- **PREVIOUS STUDIES (1982 - 1989)**
  - Mortality primarily among dabbling ducks
  - Evaluations of sediment, water, and tissue samples
  - No laboratory studies of animals conducted
  - No indication of avian diseases or pesticides
  - Munition residues identified as probable cause of mortality (data inconclusive)
  - Initial test for phosphorous in 1983
  - No suitable tissue tests for explosives

Prepared by: P. D. Smallidge

IAC ERF-3

# **SUMMARY OF FINDINGS**

- **1990 STUDY**
  - **Focus on munition**
  - **Review of munitions used in ERF**
  - **Identified need for more intensive data collection**
    - » **GRASS GIS software**
    - » **Extensive water and sediment sampling for explosives**
  - **2, 4 DNT evaluation**
    - » **Identified toxicity test**
    - » **Mortality characteristics not consistent**
    - » **2, 4 DNT limited to EOD area**
  - **White phosphorous evaluation**
    - » **Found in all waterfowl samples from ERF**
    - » **Found in sediments of waterfowl ponds**
    - » **Laboratory studies match field observations**

## **CONSEQUENCES**

- **WHITE PHOSPHOROUS IDENTIFIED AS CAUSE OF WATERFOWL MORTALITY**
- **LONG-TERM STORAGE OF WHITE PHOSPHOROUS IN ERF SEDIMENTS LIKELY**
- **PROPOSED ALTERNATIVE WINTER TRAINING SCENARIO TO 6TH ID(L)**
- **FOLLOW-ON STUDIES OF OTHER ARMY TRAINING AREAS**

**BOTTOM LINE**  
**SAVINGS TO ARMY \$22.4 MILLION**

Prepared by: P. D. Smallidge

IAC ERF-5

# **DAM BREAK ANALYSES**

**Presented by**

**Mark R. Jourdan  
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Information Analysis Center  
Waterways Experiment Station  
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**Approved for Public Release: Distribution Unlimited**

# **OBJECTIVE**

- **DOD KEY TECHNOLOGY EFFORT - ENVIRONMENTAL EFFECTS**
- **The Study, Modeling, and Simulation of Terrestrial Environmental Effects**
- **Natural and Man-Made Effects**
  - o **Examples Include**
    - **Flooding by rainfall-runoff**
    - **Flooding by reservoir release**
    - **Flooding by dam breach**
- **Impact of the Environment on Military Vehicles, Weapons, and Maneuvers**



## **EFFECTS OF DAM BREACH**

- **OBSTACLE CREATION**
- **HYDROPOWER AND NAVIGATION**
- **DOWNSTREAM STRUCTURES AND FACILITIES**
- **DECREASED THREAT OF ENEMY FLOODING**



# **DAM BREAK ANALYSIS**

- **COLLECT DAM AND TERRAIN CHARACTERISTICS**
- **PREDICT BREACH SIZE**
  - **Dependent on Breach Mechanism**
  - **Dependent on Dam Type**
- **TACTICAL DAM ANALYSIS MODEL (TACDAM)**
  - **Peak Depth**
  - **Time to Peak Depth**
  - **Time to Flood and Deflood**
  - **Area Inundation**



## **RESULTS OF DATA ANALYSIS**

- **EFFECTS OF FLOODING ON VEHICLES**
- **IMPASSABLE AREAS INDICATED**
- **TIMING OF RESULTANT FLOOD AVAILABLE**

# **CONSEQUENCES**

- **SAVINGS IN TERMS OF PRODUCTIVITY**
  - Quick Analysis Tool
  - Ability to Evaluate Many Alternatives
- **IMPROVEMENT IN MILITARY CAPABILITY**
  - Evaluate Combat Effectiveness
  - Plan Maneuver of Forces
- **RESULTS INCORPORATED INTO OPERATION PLANNING**

# RELEVANCE TO OTHER USERS

- SECONDARY USERS
  - Logistics
  - Special Operations
- STANDARD MODEL (TACDAM) DEVELOPED
  - Possible Users Include
    - o U.S. Army Terrain Teams
    - o FEMA
    - o State Agencies

## **MATERIALS AND PROCESSES**

**FACILITIES ENGINEERING APPLICATIONS PROGRAM  
(FEAP)**

**Presented By**

**Gerald W. Tumage**

**Director: Airfields, Pavements and Mobility IAC (APMIAC)  
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# CONTEXT

- FACILITIES: U.S. ARMY INSTALLATIONS WORLD-WIDE
- ENGINNERING: CONDUCTED/MANAGED BY DIRECTORATES OF ENGINEERING AND HOUSING (DEHs) AT SUCH INSTALLATIONS
- APPPLICATIONS: FEAP PROVIDES GUIDANCE TO DEHs FOR MAINTENANCE/REHABILITATION OF ARMY'S PAVEMENTS/RAILROADS
- PROGRAM: FEAP SPONSORED BY U.S. ARMY ENGINEER & HOUSING SUPPORT CENTER, FORT BELVOIR, VA
- POTENTIAL FOR SAVINGS
  - Army has over 60,000 miles of pavement, hundreds of miles of railroad
  - Improved maintenance/rehabilitation methods can save \$ hundreds of millions

## **TASKS**

- **FEAP RELATIONSHIPS TO:**
  - **DoD Key Technologies: Experiments, Materials and Processes**
  - **DoD S&T Thrust: Technology for Affordability**
  - **DoD Military Mission/Function: Civil Engineering Works**
- **19 FEAP PROJECTS (TASKS) TO DATE, INCLUDING:**
  - **Hot Mix Recycling**
  - **Cold Mix Recycling**
  - **Pavement Crack and Joint Sealing**
  - **Concrete Pavement Restoration**
  - **Pavement Evaluation**
  - **Railroad Maintenance: Flaw, Deflection Testing**
  - **Railroad Maintenance: Structural Enhancement**
  - **Geotextile Application**
  - **Dustproofing Unsurfaced Areas**



# **METHODOLOGY**

- **ORDER OF WORK**

- Identify beneficial new technology/procedure
- Coordinate with DEH
- Award contract
- Demonstrate technology/procedure to DEH
- Analyze/publish/disseminate results

- **TECHNOLOGY TRANSFER**

- User's Guides
- User Workshops
- Fact Sheets
- Information Bulletins
- Videotapes
- Ad Fillers

# **SUMMARY OF RESULTS**

## **• USER'S GUIDE STANDARDIZED FORMAT**

### **CONTENTS**

#### **PART I: EXECUTIVE SUMMARY**

- Description
- Application
- Benefits
- Limitations
- Costs
- Recommendation for Use
- Points of Contact

#### **PART II: PREACQUISITION**

- Description of Technology
- Application
- Limitations/Disadvantages
- FEAP Demonstrations/Implementation Sites
- Life-Cycle Costs
- Advantages and Benefits

#### **PART III: ACQUISITION/PROCUREMENT**

- Potential Funding Sources
- Technology Components and Sources
- Procurement Documents
- Procurement Scheduling

#### **PART IV: POST ACQUISITION**

- Initial Implementation
- Operation and Maintenance
- Service and Support Requirements
- Performance Monitoring

#### **APPENDIX A: AD FLIER**

#### **APPENDIX B: BIBLIOGRAPHY**

#### **APPENDIX C: EXAMPLE OF SPECIFICATIONS**

## **SOME FEAP RESULTS**

### **-Hot-Mix Recycling of Asphalt Concrete Pavements**

**- "... cost savings normally range from 10 to 30 percent, with savings of 50 percent encountered."**

### **-Cold-Mix Recycling of Asphalt Concrete Pavements**

**- "Cost savings ... have ranged from 10 to 30 percent."**

### **-Pavement Joint and Crack Sealing Using Field-Molded Sealants**

**- "...sealants should last 5 years... (and)... save up to \$6 million per year."**

### **-Structural Enhancement of Railroad Track**

**- "...track maintenance savings of approximately \$7,000 per mile per year are anticipated."**

## **CONSEQUENCES**

### **• SOME MORE FINANCIAL BENEFITS FROM FEAP**

- Showed that dustproofing unsurfaced gravel roads can reduce regravelling by one ton per mile annually and reduce maintenance costs by 30 percent.**
- Validated that cracking and seating portland concrete slabs before overlaying with asphalt pavement can reduce costs over \$10 per square yard.**

### **• OTHER BENEFITS FROM FEAP**

- Identified beneficial new technologies from private and government sectors**
- Demonstrated/transferred new technologies to Army**
- Obtained feedback from DEHs showing broad technology acceptance**

# **RELEVANCE TO OTHER USERS**

## **• OTHER AGENCIES THAT WOULD BENEFIT FROM FEAP FINDINGS:**

- Branches of U.S. military in addition to U.S. Army**
- State/county/city departments for highways, roads, etc.**
- Federal and private railroad agencies**

## **• MAJOR BENEFITS TO SUCH AGENCIES:**

- Objective findings from FEAP**
- Potential major savings from new technologies**
- Description of findings in standardized format (FEAP user's guides)**
- Additional FEAP technology transfer (videotapes, ad fliers, fact sheets, etc.)**

# **ADVANCED MATERIALS AND PROCESSING TECHNOLOGY WORKSHOP AND PROCEEDINGS**

**Part 1: Plenary Session and Private Sector Reactions to Congressional  
Language**

**Part 2: Workshop on Ceramic Matrix Composites**

**Prepared by**

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**Approved for Public Release; Distribution is Unlimited**

# **CONTEXT**

- **BROAD OBJECTIVE OF DOD KEY TECHNOLOGY ON MATERIALS AND PROCESSES FOR STRUCTURAL APPLICATIONS\***
    - **Materials that possess:**
      - o **Low Observable Characteristics**
      - o **High Thermal Dynamic Loading**
      - o **High Structural Integrity**
      - o **Affordable Manufacturing Processes**
- are crucial for advanced weapon systems.**

\* **DoD Key Technologies Plan (AD-A253 692, July 1992)**

Prepared by: **Said K. El-Rahaiby**

**CIAC - 2a**

# **CIAC FOCUSED WORKSHOP AND PROCEEDINGS ON ADVANCED CERAMICS**

- **SUBSET OF DOD KEY TECHNOLOGY ON MATERIALS AND  
PROCESSES FOR STRUCTURAL APPLICATIONS:**
  - **Roadmap of technology objectives**
- **THE U.S. SENATE ARMED SERVICES COMMITTEE (SASC)**
  - **Report 101-384**
- **THE HOUSE ARMED SERVICES COMMITTEE (HASC)**
  - **Report 101-665**
- **THE U.S. SENATE APPROPRIATIONS COMMITTEE (SAC)**
  - **Report 101-521**



# ROADMAP OF TECHNOLOGY OBJECTIVES\* (MATERIALS COVERED AND MONITORED BY CIAC)

Technology Set	By 1995	By 2000	By 2005
Ceramics	<ul style="list-style-type: none"> <li>• 2800 °F capable ceramic reinforcing fiber feasibility demonstrated.</li> <li>• Ceramic matrix composites transitioned to F-100 nozzle.</li> </ul>	<ul style="list-style-type: none"> <li>• 2500 °F ceramic components and thermal barrier coatings for diesel engines.</li> <li>• 2500 °F ceramic composite components demonstrated in IHPTET Phase II.</li> </ul>	<ul style="list-style-type: none"> <li>• 2800 °F cooled ceramic composite components on test in Phase III IHPTET.</li> <li>• 1000 °F ceramic bearing transitioned to turbine engine manufacturers.</li> </ul>
Armor Materials	<ul style="list-style-type: none"> <li>• Ballistic performance of Aeromet 100 optimized and integrated into aircraft armor.</li> <li>• 40% increase in capability of ceramic armor materials.</li> </ul>	<ul style="list-style-type: none"> <li>• 50% cost reduction in SiC and TiB<sub>2</sub> and full-scale process line for armor tile.</li> <li>• 30% decrease in composite armor fabrication costs.</li> <li>• 15% increase in resistance of steel armor to shear/plugging.</li> </ul>	<ul style="list-style-type: none"> <li>• 16-ton composite armored, air-droppable fighting vehicle demonstrated.</li> </ul>

\* DoD Key Technologies Plan (AD-A253 692, July 1992)

# **CIAC FOCUSED WORKSHOP AND PROCEEDINGS ON ADVANCED CERAMICS (continued)**

- **IN THE THREE CONGRESSIONAL COMMITTEE REPORTS THE FOLLOWING WAS RECOGNIZED AND EMPHASIZED**
  - **The critical importance of advanced ceramic materials in maintaining the United States' sound defense industrial base, technological superiority, and global competitiveness.**
  - **The necessity to generate quality and performance data to speed broad scale adoption of this technology by the armed forces, aerospace and commercial applications.**
  - **The need for combined efforts among U.S. government, industry, and academia in developing fabrication processes applicable to low-cost advanced ceramic materials.**

# **CIAC FOCUSED WORKSHOP AND PROCEEDINGS ON ADVANCED CERAMICS (continued)**

- **FOCUS:**
  - **What:** Obtain private sector reactions to congressional (HASC, SASC, HAC, SAC) language in fiscal year 1991, 1992 and 1993 reports

## **SPECIFICALLY--**

- **WHAT DO YOU THINK OF INDUSTRY, ACADEMIA, GOVERNMENT  
ADVANCED MATERIALS PROCESSING PARTNERSHIPS?  
(SASC FY91, 92, 93)**
  - Are they an important factor in the "U.S. ability to maintain technological superiority in national defense and global competitiveness"?
  - Why?

# **CIAC FOCUSED WORKSHOP AND PROCEEDINGS ON ADVANCED CERAMICS (continued)**

- **WHAT DO YOU THINK OF THE CONCEPT "THAT VIEWS TECHNOLOGY AND MANUFACTURING AS A CONTINUUM LINKING BASIC TECHNOLOGY DEVELOPMENT TO PRODUCTS AND SERVICES IN THE MARKET PLACE"? (HASC FY1992/1993)**
  - **Is this realizable?**
  - **How?**
  - **Assess the following:**
    - o **Cost-effective fabrication processes for ceramic matrix composites**
    - o **Numerical/technical databases on ceramic matrix composites**
    - o **Ceramic matrix composites component design and analysis**
  - **Who:      Office of the Director of Defense Research and Engineering (Advanced Technology)**

# **CIAC FOCUSED WORKSHOP AND PROCEEDINGS ON ADVANCED CERAMICS (continued)**

-- **Form: Advanced Materials and Processing Technology  
Workshop and Proceedings**

**Part 1: Plenary Session and Private Sector Reactions  
to Congressional Language (CIAC Special  
Report (Part 1), August 1991)**

**Part 2: Workshop on Ceramic Matrix Composites  
(CIAC Special Report 1 (Part 2), August 1991)**

Prepared by: **Said K. El-Rahaiby**

**CIAC - 8a**

# **CIAC METHODOLOGY**

- **METHODOLOGY USED TO PERFORM WORK**
  - **Workshop participated by experts (70 participants) to give state-of-the-art technical presentations on:**
    - o **Cost-effective fabrication processes for ceramic matrix composites (8 presentations)**
    - o **Numerical/technical databases on ceramic matrix composites (9 presentations)**
    - o **Ceramic matrix composites component design and analysis (5 presentations)**
  - **Round table discussions among experts**
  - **Review of available information from literature**
- **CIAC UNIQUE APPROACH**
  - **Gather experts to participate in a focused workshop**
  - **Immediate collection and dissemination of state-of-the-art information and data**
  - **Opinions collected, analyzed, and presented**

# **SUMMARY OF DATA**

- **RESPONSES TO QUESTIONNAIRE COMPILED, ANALYZED, AND SUMMARIZED**
- **MANUSCRIPTS AND VIEWGRAPHS COLLECTED FROM PRESENTORS**
- **ROUND TABLE DISCUSSIONS EDITED AND SUMMARIZED**
- **PROCEEDINGS PUBLISHED AND DISTRIBUTED TO AUTHORIZED USERS**

## **RESULTS OF DATA ANALYSIS**

- **CMCs ARE VIABLE MATERIALS FOR ALL TEMPERATURE APPLICATIONS**
- **CMCs SHOULD BE PERMITTED TO COMPETE FOR APPLICATIONS ACROSS A BROAD SPECTRUM. SIMPLE APPLICATIONS ALLOW DEVELOPMENT OF SIMPLER PRODUCTION METHODS**
- **MANUFACTURING OF ADVANCED CERAMIC COMPOSITES, UNLIKE TRADITIONAL MATERIALS ARE BASED ON PATENTED FABRICATION PROCESSES. MORE RESEARCH NEEDS TO BE DONE TO BRING COST DOWN**
- **CONSORTIA COULD BE USEFUL IN ADDRESSING COMMON MANUFACTURING PROBLEMS**



## **RESULTS OF DATA ANALYSIS (continued)**

- **A BETTER WORKING SCHEME FOR COLLABORATIVE INDUSTRY/GOVERNMENT/ACADEMIC RESEARCH PROGRAMS IS NEEDED**
- **THERE IS A LACK OF FUNDAMENTAL RESEARCH ON PRACTICAL MANUFACTURING MATTERS**
- **THERE IS A GROWING NEED FOR ANALYZED AND EVALUATED PROPERTY DATA (MECHANICAL, THERMAL AND ESPECIALLY FATIGUE AND LIFE CYCLE DATA)**

## **CONSEQUENCES**

- **THE RESULTING PROCEEDINGS ON ADVANCED MATERIALS PROVIDES THE FOLLOWING WITH STATE-OF-THE-ART INFORMATION AND DATA FOR R&D PROGRAMS ON CMCs:**
  - **The U.S. Senate Armed Services Committee**
  - **The House Armed Services Committee**
  - **The U.S. Senate Appropriations Committee**
  - **DoD funding agencies**
  - **Other Government funding agencies (such as the Department of Energy, the Department of Transportation, and NASA)**
  - **Various industrial organizations (since CMCs technology is a Dual-Use Technology)**

## **RELEVANCE TO OTHER USERS**

- **CMCs TECHNOLOGY IS RELEVANT TO AEROSPACE AND INDUSTRIAL APPLICATIONS IN ADDITION TO MILITARY APPLICATIONS**
- **METHODOLOGY USED IN THIS WORK FOR CMCs TECHNOLOGY CAN BE USED FOR OTHER ADVANCED MATERIALS TECHNOLOGIES SUCH AS:**
  - **Polymer matrix composites technology**
  - **Carbon matrix composites technology**
  - **Metal matrix composites technology**

**ASSESSMENT OF THE STATUS OF CERAMIC  
MATRIX COMPOSITES TECHNOLOGY IN THE  
UNITED STATES AND ABROAD**

**Prepared by**

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**Approved for Public Release; Distribution is Unlimited**

# **CONTEXT**

- **BROAD OBJECTIVE OF DOD S&T SEVEN THRUST AREAS\***
  - **Seek to promote and leverage the information technology explosion, adapting and converting it into military technologies that will revolutionize military operations.**
  - **Gain clear visibility into the worldwide reservoir of scientific knowledge and rapidly exploit scientific advances they may originate.**
  - **Facilitate the transition of research results to further stages of the defense development cycle.**
  - **Strengthen the research infrastructure in defense labs, and in the academic non-profit labs which serve the DoD to meet critical defense needs.**
  - **Facilitate the spin-off, where appropriate, of defense research results to the civil and commercial sectors.**

## **CONTEXT (continued)**

- **BROAD OBJECTIVE OF DOD KEY TECHNOLOGY AREA ON MATERIALS AND PROCESSES**
  - Development of man-made materials (e.g., composites, electronic and photonic materials, smart materials) for improved structures, higher temperature engines, signature reduction, and electronics, and the synthesis and processing required for their application.
- **DOD MILITARY MISSION/FUNCTION**
  - Domestic technology transfer (from lab to application)
  - Technology transfer to "dual use" applications
- \* **Defense Science and Technology Strategy (AD-A253 691, July 1992)**

# **CIAC STATE-OF-THE-ART REPORT ON CERAMIC MATRIX COMPOSITES**

- **SUBSET OF DOD S&T THRUST AREA:**

- **Precision Strike**

**Materials and Processes--Low observables, resistance to thermal dynamic heating, high structural loading integrity, and affordable manufacturing processes are crucial for advanced weapon systems.**

- **Advanced Land Combat**

**Materials and Processes--Lightweight composite structures are critical to the weight reduction of armed vehicles.**

**Ceramic matrix composites (CMCs) have demonstrated the potential for dramatic improvements in weapon systems.**

# **CIAC STATE-OF-THE-ART REPORT ON CERAMIC MATRIX COMPOSITES (continued)**

- **FOCUS: STATUS OF CERAMIC MATRIX COMPOSITES IN THE U.S.  
AND ABROAD**

-- **What: Provide data and information to assess**

- o Effectiveness of U.S. investments on CMCs technology
- o Potential effects on current and future military capabilities
- o U.S. industrial base
- o U.S. technological base
- o Foreign technology on CMCs
- o U.S. worldwide competitive posture
- o Important R&D directions

-- **Who: Office of the Director of Defense Research and  
Engineering (Advanced Technology)**

-- **Form: CMCs technology assessment resulted in a state-of-  
the-art report (CIAC Report 1, April 1991)**



# CIAC METHODOLOGY

- **METHODOLOGY EMPLOYED**
  - Questionnaire survey
  - Workshop participated by experts
  - Review of available information from literature
  - Telephone interviews
- **CIAC UNIQUE APPROACH**
  - Define overall problem
    - o Type of matrices
    - o Type of reinforcements
    - o Composite making
  - Define areas of applications
    - o Military
      - Air Force
      - Army
      - Navy
    - o Aerospace
    - o Commercial

## **CIAC METHODOLOGY (continued)**

- Define other government agencies sponsoring programs on same materials**
- New information is created in the form of opinion expressed by CMCs experts through face-to-face discussions and compiled data and information from literature**

# **SUMMARY OF DATA**

- **DATA AND INFORMATION COLLECTED ON CMCs:**
  - **Technology**
  - **Processing and manufacturing**
  - **Current DoD programs**
  - **Current NASA and DoE programs**
  - **Test and test methods**
  - **Standardization methods**
  - **Foreign technology**
  - **Future needs and directions**
- **ORGANIZATION OF DATA AND INFORMATION**
- **REPORT ASSEMBLY**
- **FOLLOW-ON WORKSHOP**
- **FURTHER COMMENTS AND SUGGESTIONS FROM REVIEWERS**

## **RESULTS OF DATA ANALYSIS**

- **SUMMARY OF FINDINGS**
  - **U.S. has an excellent science base but does not capitalize well on it**
  - **Although CMCs are new materials, some have already been applied to weapon systems**
    - o **LAV-25 armored vehicle fitted with removable "ceramic composite tiles" to protect it against heavy artillery.**
    - o **Helicopters also fitted with light-weight ceramic armor.**
    - o **Patriot missile equipped with ceramic radome to protect radar system from severe environments**
  - **U.S. has limited technological and industrial bases**
  - **U.S. is dependent on Japan and Germany for best ceramic fibers and powders**
  - **Foreign countries are actively pursuing the development of CMCs**

## **RESULTS OF DATA ANALYSIS (continued)**

- Future Needs**
  - o High temperature ceramic fibers made in U.S.
  - o Interface structures control and optimization of fiber/interface/matrix system
  - o Processing
    - Development of cost-effective methods
    - Near net shape capability
  - o Standardized test methods on mechanical properties
  - o component design methodology and analysis
  - o Design databases
  - o Environmental durability of CMCs

## **CONSEQUENCES**

- **THE RESULTING STATE-OF-THE-ART REPORT ON THE STATUS OF CMCs TECHNOLOGY IN THE U.S. AND ABROAD PROVIDES THE FOLLOWING WITH STATE-OF-THE-ART INFORMATION FOR THE PLANNING OF R&D PROGRAMS ON CMCs:**
  - **DoD funding agencies**
  - **Other Government funding agencies (such as the Department of Energy, the Department of Transportation, and NASA)**
  - **Various industrial organizations (since CMCs technology is a Dual-Use Technology)**

## **RELEVANCE TO OTHER USERS**

- **CMCs TECHNOLOGY IS RELEVANT TO AEROSPACE AND INDUSTRIAL APPLICATIONS IN ADDITION TO MILITARY APPLICATIONS**
- **METHODOLOGY USED IN THIS WORK FOR THE ASSESSMENT OF CMCs TECHNOLOGY CAN BE USED FOR THE ASSESSMENT OF OTHER ADVANCED MATERIALS TECHNOLOGIES SUCH AS:**
  - **Polymer matrix composites technology**
  - **Carbon matrix composites technology**
  - **Metal matrix composites technology**

**HIGH TEMPERATURE MATERIALS PROPERTIES  
ONLINE NUMERIC DATABASE CAPABILITY FOR  
DUAL-USE TECHNOLOGY TRANSFER**

**Prepared by**

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**Approved for Public Release; Distribution is Unlimited**



# CONTEXT

- **SUPPORT TO:**
  - **DoD Military Mission/Function**
    - o Dual-Use Technology Transfer
    - o Professional Military Education
  - **DoD Key Technology Area**
    - o Materials and Processes
    - o Sensors
  - **DoD Science and Technology Thrust**
    - o Technology for Affordability
    - o Advanced Land Combat
- **OBJECTIVE**
  - **Electronic storage and dissemination of numeric data on advanced materials for both military and industrial applications**

# **HTMIAC BASIC INFORMATION PRODUCT**

- **SUBSET OF DOD MILITARY MISSIONS**
  - **High Temperature Materials Properties (HTMP) database**  
contributes to domestic technology transfer
  - **Materials properties data and information are integral**  
components of the military dual-use and domestic technology  
transfer missions
- **HIGH TEMPERATURE MATERIALS PROPERTIES (HTMP) ONLINE  
NUMERIC DATABASE CAPABILITY**
  - **What:** Develop an electronic database containing data and  
information on material properties
  - **Who:** Defense Technical Information Center (DTIC)
  - **Form:** Computerized database, online accessible (telephone  
line connection) from user's own personal computer or  
computer terminal

# HTMIAC METHODOLOGY

- **METHODOLOGY EMPLOYED**
  - **Data Collection:**
    - o Material property data within HTMIAC scope searched from open literature and analyzed for factors that influence property behavior
  - **Data Analysis:**
    - o Material processing
    - o Material characterization
    - o Property test method
    - o Material conditioning/environmental exposure
    - o Experimental variables
  - **Data Synthesis:**
    - o Basic unit of data and information is "data set"
    - o Design and creation of database file structure
    - o Design and creation of ancillary database files
    - o Design of data search strategies and creation of enabling software
    - o Implementation of online access
    - o Development of graphical display option

# METHODOLOGY (continued)

## ● APPROACH FOLLOWED

- Features of HTMP Online Numeric Database:
  - o Content of Database
    - Centralized source of scientific and technological data and information on high temperature materials properties
    - Materials include aerospace structural polymer-matrix composites, carbon/carbons and alloys, infrared detector materials, and coatings for optical components
  - o Computerization Aspects
    - Remote access, instant retrieval, electronic dissemination of data
    - Linkup is by personal computer/terminal, modem, and telephone/data line
- Data and Information Sources:
  - o Material property data were captured from available open literature
- New Information Created:
  - o Online capability enables fully electronic dissemination of data and information

# SUMMARY OF DATA

- DATA COLLECTED

- Property data for high temperature materials of current interest:
  - Properties include thermophysical, thermoradiative, ablative, mechanical, electronic, and optical
  - Materials include aerospace structural polymer matrix composites, carbon/carbons and alloys, infrared detector materials, and coatings for optical system components
  - Pertinent information includes: material characterization, material processing, test method, and material conditioning
  - Current statistics show 18,600 data sets for 1,010 specific material names

- Interesting Characteristics:

- When viewed as a centralized data resource, the database contains a remarkable variety of information
- The database is the only online-accessible, computer-searchable database of its size and type

# **RESULTS OF DATA ANALYSIS**

- **FINDINGS RESULTING FROM ANALYSIS OF THE COLLECTED DATA**
  - The amount of data is significant, the number of materials and properties is surprisingly large, and the variety of experimental variables is remarkable
  - A database of this type can become a primary means for electronic dissemination of numerical data and information from DoD laboratory sources to user communities anywhere
- **SUMMARY OF TECHNICAL RECOMMENDATIONS**
  - Send us a letter request, and we will send you a login and password

# CONSEQUENCES

- **WHAT HAS HAPPENED AS A RESULT OF COMPLETION OF THIS PRODUCT?**
  - **A centralized source of property data and information on high temperature materials was made available for remote, online access to qualified users**
  - **Financial Benefits to DoD**
    - o **Savings from having a large, single-source data and information resource readily available**

## **RELEVANCE TO OTHER USERS**

- **RELATED SUBSTANTIVE PROBLEMS FOR WHICH THE HTMP ONLINE DATABASE WOULD BE RELEVANT**
  - Any materials and processing DoD key technology area activity will be interested in accessing a single-source numeric data resource
- **ANALOGOUS PROBLEMS FOR WHICH THE HTMP ONLINE DATABASE WOULD BE RELEVANT BECAUSE OF THE DATA/METHODOLOGY USED**
  - Methodology used for collection, analysis, and compilation of data and information can be used for any materials and properties



**DATABASE ON LASER-INDUCED DAMAGE  
THRESHOLD FOR STRATEGIC FORCES  
AND MISSIONS**

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# CONTEXT

- **SUPPORT TO:**
  - **DoD Military Mission/Function**
    - o **Strategic Forces: Detection and Warning**
    - o **DoD Missions: Dual Use and Technology Transfer**
  - **DoD Key Technology Area**
    - o **Sensors**
    - o **Materials and Processes**
  - **DoD Science and Technology Thrust**
    - o **Global Surveillance and Communications**
    - o **Precision Strike**
    - o **Air Superiority and Defense**

# HTMIAC BASIC INFORMATION PRODUCT

- SUBSET OF DOD MILITARY MISSION/FUNCTION
  - Detection and warning function is enhanced by laser-hardening components of detection systems
- HTMIAC DATABASE ON LASER-INDUCED DAMAGE THRESHOLDS FOR SEMICONDUCTOR DETECTOR MATERIALS
  - What: Create a database on laser-induced damage threshold (LIDT) data for semiconductor materials
  - Who: Mr. Peter D. Hughes at CALSPAN Corporation, White Sands, New Mexico
  - Form: Compiled literature data for LIDT of several semiconductor materials (Si, Ge, GaAs, InSb, HgCdTe, PbSnTe)

# HTMIAC METHODOLOGY

- **METHODOLOGY EMPLOYED**
  - **Data Collection:** Comprehensive search of open literature for LIDT data on semiconductor detector materials (Si, Ge, GaAs, InSb, HgCdTe, PbSnTe)
  - **Data Analysis:** Search for factors that influence the LIDT
    - o Material characterization
    - o Laser beam parameters (wavelength, intensity/fluence, spot size, CW, RP, pulse duration)
    - o Detection and definition of LIDT
    - o Modeling of results
  - **Data Synthesis:** Compilation of analyzed LIDT data into database for dissemination
    - o Selection criteria derived from analysis results
    - o Basic unit of compiled data and technical information is "Data Set"
    - o Diskette copy was requested

# **HTMIAC METHODOLOGY (continued)**

- **APPROACH FOLLOWED**
  - **Features of HTMIAC Database**
    - Comprehensive compilation of analyzed data identified from extensive searches of open literature
    - Includes information on: material characterization, laser-beam parameters, LIDT definition and detection, modeling results (when available)
    - Data source references are included
  - **Added Value: Creation of a single-source of analyzed data for LIDT of semiconductor materials**

# SUMMARY OF DATA

- DATA COLLECTED

- Data Search Results

- o 72 sets of LIDT data for 7 semiconductors: Ge - 20, Si - 16, GaAs - 14, InSb - 5, HgCdTe - 9, PbSnTe - 4, Si PIN Diode - 4
    - o 27 distinct material types (material variables: dopants, stoichiometry, photovoltaic/photoconductor configuration)
    - o 25 data sources are referenced with publication dates from 1976 to 1988 (Boulder Damage Symposia, early LIDT work from Naval Research Laboratory, a recent review by Wood (1986))
    - o Laser wavelengths were mostly either 10.6  $\mu$  or 1.06  $\mu$  with a few other (5.0, 2.94, 2.76, 0.69, 0.248  $\mu$ )

- Interesting Characteristics

- o Extensive technical information for material characterization, laser-beam parameters, and LIDT definition was reported by several sources
    - o Pulsed laser beams (rather than continuous wave) were nearly always used
    - o Naval Research Laboratory (Bartoli et al.) was very active in development of models for pulsed laser damage thresholds

# **RESULTS OF DATA ANALYSIS**

- **FINDINGS RESULTING FROM THE DATA ANALYSIS**
  - The most complete sets of available data and information are for longer wavelengths. Extensions to shorter wavelengths are usually lacking
  - Widespread differences exist in the way that damage is detected and defined (use of visible damage or electrical failure depends upon application)
  - Development of predictive models for thermal damage requires extensive knowledge of material properties
- **SUMMARY OF TECHNICAL RECOMMENDATIONS**
  - Considerable caution should be exercised when using damage threshold data due to the large number of factors involved

# CONSEQUENCES

- **WHAT HAS HAPPENED AS A RESULT OF COMPLETION OF THIS TECHNICAL INQUIRY?**
  - The resulting database provides the data and information resource for semiconductor materials that was requested
  - Financial Benefits to DoD
    - o The database is a single-source, data and information resource for LIDT of semiconductor materials
    - o Real cost savings are due to the ease and convenience of searching a personal computer diskette



## **RELEVANCE TO OTHER USERS**

- **RELATED SUBSTANTIVE PROBLEMS FOR WHICH THE HTMIAC PRODUCT WOULD BE RELEVANT**
  - In broad terms, the database would be relevant to many activities in the Sensors or Materials and Processes DoD Key Technology Areas and in the Precision Strike S&T Thrust that deal with detector materials
- **ANALOGOUS PROBLEMS FOR WHICH THE HTMIAC PRODUCT WOULD BE RELEVANT BECAUSE OF THE DATA OR METHODOLOGY USED**
  - Methodology can be applied to creation of an electronic database for LIDT of other materials (i.e., optically transparent materials)

**COMPUTERIZATION OF PROPERTIES OF  
AUSTEMPERED DUCTILE IRON (ADI)**

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# **CONTEXT**

- **BROAD OBJECTIVE OF DOD S&T THRUST AREA ON ADVANCED LAND COMBAT**
  - The ability to rapidly deploy our ground forces to a region, exercise a high degree of tactical mobility, and overwhelm the enemy quickly and with minimal casualties in the presence of a heavy armored threat and smart weaponry requires highly capable land combat systems.
- **BROAD OBJECTIVE OF DOD KEY TECHNOLOGY AREA ON MATERIALS AND PROCESSES**
  - The DoD Materials and Processes technology area spans the spectrum of structural, thermal protection, non-structural, and electronic materials. Cost-effective, integrated manufacturing technology is implicitly included in each of the above materials areas.
- **DOD MILITARY MISSION/FUNCTION**
  - Ground Forces
  - Domestic Technology Transfer

# **MIAC TASK/INFORMATION PRODUCT**

- **SUBSET OF DOD MILITARY MISSION/FUNCTION**
  - **Armor/systems**
    - o **Track System for M1/A1 Tank and Bradley Vehicle**
  - **Artillery/systems**
    - o **155 mm Shell Bodies in M864 Artillery Round**
- **MIAC TASK/INFORMATION PRODUCT FOCUS**
  - **What: Collect and computerize existing information/data on physical and mechanical properties of Austempered Ductile Iron (ADI)**
  - **Who: U.S. Army Research Laboratory Materials Directorate**
  - **Form: Computerized PC-based numeric database on properties of ADI**

# **MIAC METHODOLOGY**

- **METHODOLOGY EMPLOYED**
  - **Data compilation from articles published in worldwide literature**
    - o **Chemistry**
    - o **Processing**
    - o **Testing**
    - o **Propertles**
  - **Data analysis and computerization**
  - **Development of interactive, menu-driven, pc-based numeric database**
- **APPROACH**
  - **MIAC Uniqueness**
    - o **Experience in numeric database development**
    - o **Ability to analyze data**
  - **Existing Information**
    - o **Published Information and data are analyzed and compiled in computer readable format**
  - **New Information**
    - o **Analyzed and compiled data in a PC-based numeric database**

# **SUMMARY OF DATA**

- **DATA COMPILATION**
  - **Compiled datasets covering properties of ADI**
    - o **Mechanical Properties**
      - **Tensile/compressive behavior**
      - **Hardness and toughness**
      - **Fatigue**
      - **Impact and wear**
    - o **Physical Properties**
      - **Retained Austenite**
      - **Nodularity and melt chemistry**
      - **Hardenability**
      - **Damping response**
- **CHARACTERISTICS**
  - **Data depend strongly on chemistry and processing**

# **RESULTS**

- **FINDINGS RESULTING FROM DATA ANALYSIS**
  - **Properties of ADI depend strongly on chemistry, thermal history, and processing**
  - **Specification standards are available only in U.S. and Japan**
  - **Many ADI producers do not adhere to established standards**
- **TECHNICAL RECOMMENDATIONS**
  - **Establish MIL SPEC standards**
  - **Tight control of chemistry and processing for desired properties**

# **CONSEQUENCES**

- **WHAT WILL HAPPEN AS A RESULT OF THE COMPLETION OF THIS MIAC PRODUCT**
  - **Computerized pc-based numeric database on properties of ADI will help evaluate its applications**
    - o Supporting Research on ADI
  - **Financial Benefits to DoD**
    - o Cut production cost
    - o Increase in lifetime of parts
  - **Other Benefits to DoD**
    - o Improvement in existing armored vehicle designs
    - o Reduced acoustic signature (improved stealth)
    - o Tougher, longer lasting, more dependable parts



# **RELEVANCE TO OTHER USERS**

- **RELATED SUBSTANTIVE PROBLEMS FOR WHICH MIAC PRODUCT WOULD BE RELEVANT**
  - Currently there is no comprehensive source of Information on ADI
  - Numeric database on properties of ADI is also useful to industry
    - o Automotive manufacturers
    - o Machine, gear manufacturers
    - o Foundries
- **ANALOGOUS PROBLEMS FOR WHICH MIAC PRODUCT WOULD BE RELEVANT BECAUSE OF THE METHODOLOGY USED**
  - Data collection and analysis methodology applicable to a broad range of materials
    - o HSLA Steel
    - o Super Alloys
    - o Intermetallics

**CORROSION IN DOD SYSTEMS:  
DATA COLLECTION AND ANALYSIS**

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# CONTEXT

- OBJECTIVES
  - Reduce Costs due to Corrosion
  - Improve Battle Readiness
- RELATED DOD THRUSTS/MILITARY FUNCTIONS
  - Sea Control and Undersea Superiority
  - Air Superiority and Defense
  - Technology for Affordability
  - Advanced Land Combat

## **MIAC TASK/INFORMATION PRODUCT**

- **IDENTIFICATION OF CORROSION ISSUES AND FACTORS**
  - **Detection**
  - **Mitigation**
  - **Prevention**
- **SELECT MAJOR SYSTEM AS EXAMPLE**
  - **Field Visits**
- **QUALITATIVE ASSESSMENT OF COSTS**

# **MIAC METHODOLOGY**

- **REVIEW APPROXIMATELY 24,000 DROLS REFERENCES**
  - **Materials**
  - **Systems**
  - **Detection**
  - **Mechanisms**
  - **Avoidance**
- **VISITATIONS AND FIELD DATA COLLECTION**
  - **Research and Development Efforts**
  - **Logistics and Operations**
- **COMBINING LITERATURE REVIEW AND FIELD DATA**

# **SUMMARY OF DATA**

- **DATA REVIEW**

- **Materials**

- **Mechanisms**

- **Detection**

- **Systems**

- **Avoidance**

- **FIELD VISITS**

- **Extent of Problem**

- **Effect on Combat Readiness**

- **Qualitative Costs**

# **ANTICIPATED RESULTS**

- **DATA ANALYSIS**
  - **Materials Data Related to Structural Systems/Applications**
    - **Mechanisms**
    - **Environments**
    - **Processes**
  - **Applicable to Most DoD Thrust Areas**
- **TECHNICAL RECOMMENDATIONS**
  - **Assessment of Impact**
  - **System Support**

# **CONSEQUENCES**

- **ANTICIPATED RESULTS**
  - **Cost Avoidance**
    - **Reduced Life Cycle Costs**
  - **Improved Combat Readiness**
- **IDENTIFICATION OF MAJOR FACTORS**
  - **Maintenance**
  - **Procurement**



## **RELEVANCE**

- **CORROSION IS A MAJOR STRUCTURAL PROBLEM AFFECTING  
MANY MAJOR SYSTEMS**
- **MIAC PRODUCT HAS BROAD APPLICATIONS WITHIN DOD AND  
VARIOUS INDUSTRIES**
  - **Comprehensive Materials/Corrosion Data Set**
  - **Materials Characterization**
  - **Environmental Effects**
  - **Review and Assessment of Field Problems**
  - **Recommendations/Directions**

**ENGINEERED MATERIALS BRIEFING AT THE  
CAPITAL METALS AND MATERIALS FORUM**

**Prepared by**

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# **CONTEXT**

- **DUAL-USE TECHNOLOGIES**
  - **Technologies That Both Meet Defense Needs and Have Commerical Potential**
- **DUAL-USE TECHNOLOGY OBJECTIVES**
  - **Improved Efficiency for DoD RDT&E**
  - **Improved International Competitiveness of US Industry**
  - **Transition Defense Industry to Commercial Production**
  - **Account for 10-20% DoD R&D Funds**

# **MMCIAC TASK/BASIC INFORMATION PRODUCT**

- **DOMESTIC TECHNOLOGY TRANSFER**
- **MMCIAC TASK/INFORMATION PRODUCT FOCUS**
  - **Educate US Government Officials about Dual-Use Potential of Composites**
  - **Requested by Department of The Interior, US Bureau of Mines**
  - **Formal Briefing at Capital Metals and Materials Forum, 9 September 1993**

# **MMCIAC METHODOLOGY**

- **METHODOLOGY USED TO PERFORM WORK**
  - **Data Collection**
    - Attend Wright Laboratory Technology Reinvestment Workshop
    - Collect Literature on ARPA TRP
    - Attend WL/ML-MT Combined Roadmap Review
    - Collect International Literature and Vendor Data
  - **Data Analysis**
    - Compare Literature and WL Roadmaps
    - Review Interest of Industrial Attendees at TR Workshop
    - Brainstorm
  - **Data Synthesis**
    - Prepare Briefing Materials
    - Write Informal Paper
- **APPROACH**
  - **Provide Technical Results Usable by Nontechnical Audience**
  - **Convert Data in DROLS and Scientific Literature to Short, Informal Report**
  - **Create a New Viewpoint for Considering DoD Technology**

## **SUMMARY OF DATA**

- **DATA COLLECTED**
  - **DoD Technical Reports**
  - **Scientific Literature**
  - **DoD R&D Plans**
  - **Contractor Projections**
- **DATA CHARACTERISTICS**
  - **Materials R&D Trends and Projections**
  - **Commonality of Defense and Commercial Requirements**

# **RESULTS OF DATA ANALYSIS**

- **FINDINGS RESULTING FROM THE ANALYSIS OF DATA COLLECTED BY MMCIAC**
  - **Composite Materials Represent a Mature DoD Technology**
  - **Potential for Defense Conversion is Limitless**
  - **Commercial Users are Unaware of Dual-Use Potential**
- **SUMMARY OF TECHNICAL RECOMMENDATIONS**
  - **DTIC IACs are Important for Successful Defense Conversion**
  - **Informal Paper Should be Expanded to a CR/TA**

# **CONSEQUENCES**

- **GOVERNMENT AWARENESS**

- Department of Interior and Department of Commerce  
Introduced to DTIC IAC Program

- International Trade Commission Now Utilizing IACs

- CIAC
- HTMIAC
- MIAC
- MMCIAC
- MTIAC
- NTIAC

- **INDUSTRY AWARENESS**

- Department of Commerce Publicizing DTIC IAC Program

- MMCIAC Asked to Participate in Planning Sessions



## **RELEVANCE TO OTHER USERS**

- **RELATED OR ANALAGOUS SUBSTANTIVE PROBLEMS FOR WHICH THE ENGINEERED MATERIALS BRIEFING WOULD BE RELEVANT**
  - **Presentations to Any Groups Desiring an Introduction to the State of the Art of Advanced Composite Materials From a Marketplace Prospective**
- **RELATED OR ANALAGOUS PROBLEMS FOR WHICH THE ENGINEERED MATERIALS BRIEFING WOULD BE RELEVANT BECAUSE OF THE DATA OR METHODOLOGY USED**
  - **Introduction to Composites for the Layperson**
  - **Introduction of Technical Personnel to Dual-Use of Composites Technology**

**BIBLIOGRAPHIES PREPARED FOR VARIOUS DOD  
SMALL BUSINESS INNOVATIVE RESEARCH  
(SBIR) PROGRAM SOLICITATION TOPICS**

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# CONTEXT

- DOD KEY TECHNOLOGY: MATERIALS AND PROCESSES
  - Technology Which Delivers Materials Exhibiting Previously Unachieved or Undemonstrated Mechanical/Physical Properties and Performance, Producibility, Low Cost, and Environmental Compatibility, the Attainment of Which Enables the Timely Development of Next Generation and Future Systems
- MATERIALS AND PROCESSES TECHNOLOGY OBJECTIVE
  - Maintain the Technical Superiority and Technical Leadership Position of the United States
    - Develop Methodologies, Tools, and Disciplines Required to Increase the Competitive Advantage of our Technology Base and which are Keystone for Significantly Enhanced Functional Capabilities

# **MMCIAC TECHNICAL AREA TASK**

- **PERTINENT TO MATERIALS AND PROCESSES TECHNOLOGY FOR AFFORDABILITY AND DOMESTIC TECHNOLOGY TRANSFER**
- **TASK FOCUS: BIBLIOGRAPHIC SEARCHES IN SUPPORT OF THE DOD SBIR PROGRAM**
  - **Prepare Technical Information Packages (TIPs) on 10 SBIR Solicitation Topics Relevant to MMCIAC**
  - **Requested by DTIC-AI/Dr. Forrest R. Frank**
- **DTIC OBJECTIVES**
  - **Determine Whether IACs can Provide Bibliographic Support to SBIR Program Qualitatively Superior to that Provided by DTIC**
  - **Determine Marginal Cost Differences to the SBIR Program of Relying on IACs for SBIR Phase I Bibliographic Support**

# **MMCIAC METHODOLOGY**

- **REVIEWED SBIR SOL 93.1 AND SELECTED 10 RELEVANT TOPICS FOR BIBLIOGRAPHIC SEARCHES**
- **TECHNICAL PERSONNEL SELECTED SEARCH TERMS FOR EACH TOPIC**
- **CONDUCTED BIBLIOGRAPHIC SEARCHES**
  - **Bibliographic Data Collection**
- **SEARCHED BASIC DTIC DROLS DATABASE, DTIC DROLS MATERIALS IAC (CIAC, HTMIAC, MIAC, MMCIAC) AND MATERIALS RELATED IAC (MTIAC, NTIAC) DATABASES, AND ENGINEERING INDEX DATABASE**
- **TECHNICAL PERSONNEL REVIEWED INTERMEDIATE RESULTS AND ITERATED ON SEARCH TERMS TO IMPROVE QUALITY AND NUMBER OF SEARCH "HITS" ACHIEVED**
- **ASSEMBLED SEARCH RESULTS INTO TIP FORMAT AND TRANSMITTED PRODUCTS TO DTIC**

# **SUMMARY OF DATA COLLECTED BY MMCIAC**

- **TEN BIBLIOGRAPHIC SEARCH TIPS PREPARED, ONE FOR EACH OF THE FOLLOWING SBIR SOL 93.1 TOPICS:**
  - **Adaptive/Tunable Composite Structures**
  - **Advanced Lightweight Armor Concepts**
  - **High Temperature Advanced Composite Drive Shaft**
  - **Innovative and Durable Flexible Shafts for Power Transmission in Unmanned Air Vehicle Propulsion Systems**
  - **Innovative Heat Pipe Cooling System**
  - **Joining of Composite Materials**
  - **Metal Matrix Composite Components**
  - **Powder Metallurgy Processes for Net-Shape Complex Parts Using Dissimilar Materials**
  - **Subsystem Research - Appurtenance Attachments for Composite Systems**
  - **Tribological Coatings for Wear Applications**

# **RESULTS OF DATA ANALYSIS**

- **FINDINGS RESULTING FROM THE ANALYSIS OF THE BIBLIOGRAPHIC DATA COLLECTED BY MMCIAC FOR THE TIPS:**
  - **A Large Number of Valid Hits Were Achieved for Each Topic**
  - **Most of the Hits Were From the DTIC DROLS IAC and Engineering Index Databases, for Most of the SBIR Solicitation Topics**
- **SUMMARY OF TECHNICAL RECOMMENDATIONS FOUND IN THE TIPS:**
  - **Because of Purpose of this Task, None Were Made in the TIPS**

# **CONSEQUENCES**

- **USER FEEDBACK INDICATES USEFULLNESS/RELEVANCY OF IAC PREPARED TIPS ABOUT TWICE THAT OF DTIC IN-HOUSE PREPARED TIPS, ON THE AVERAGE**
  - **DTIC SBIR PM Very Pleased**
  - **Financial Benefits to DoD in Terms of Improved Productivity**
- **DTIC SBIR PM DESIRES TO UTILIZE IACS AGAIN IN FUTURE TO PREPARE TIPS**
  - **Ground Rules and Funding Mechanisms Need to be Established Before Such Use can be Initiated**



# **RELEVANCE TO OTHER USERS**

- **REQUESTING SIMILAR BIBLIOGRAPHIC SEARCHES BY MMCIAC OR OTHER MATERIAL-RELATED IACS SHOULD BE A FIRST STEP FOR ALL RESEARCH AND DEVELOPMENT EFFORTS POTENTIALLY INVOLVING MMC OR OTHER MATERIALS, TO IDENTIFY**

**--Work Already Done or in Progress**

**--Work Not Done or in Progress**

**--Existing Manufacturing and Processing Information**

**--Existing Properties Data**

**--Existing Applications of the Material Class**

**--Other State of the Art Items**

**SILICON-CARBIDE/MAGNESIUM COMPOSITES  
BIBLIOGRAPHY**

**Prepared by**

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**Approved for Public Release; Distribution is Unlimited**

# CONTEXT

- **DOD KEY TECHNOLOGY: MATERIALS AND PROCESSES**
  - Technology which delivers materials exhibiting previously unachieved or undemonstrated mechanical/physical properties and performance, producibility, low cost, and environmental compatibility, the attainment of which enables the timely development of next generation and future systems
- **MATERIALS AND PROCESSES TECHNOLOGY OBJECTIVE**
  - Maintain the technological superiority and technical leadership position of the United States
    - o Develop methodologies, tools, and disciplines required to increase the competitive advantage of our technology base and are keystone for significantly enhanced functional capabilities

# **MMCIAC BASIC INFORMATION PRODUCT**

- **PRODUCT APPLICABLE TO ADVANCED LAND COMBAT S&T THRUST**
  - **Ground-based interceptors, armor/systems, artillery/systems**
- **PRODUCT FOCUS: RESPONSE TO USER INQUIRY**
  - **Prepare bibliography on silicon carbide reinforced magnesium matrix composites (SiC/Mg)**
  - **Requested by U.S. Army Research Laboratory (ARL)/MAMB (Perry R. Smoot)**
  - **Bibliographic search conducted; printed bibliography transmitted**

# **MMCIAC METHODOLOGY**

- **TECHNICAL PERSONNEL SELECTED SEARCH TERMS FOR THE TOPIC**
- **BIBLIOGRAPHIC SEARCH CONDUCTED**
  - **Bibliographic Data Collection**
  - **SEARCHED BASIC DTIC DROLS DATABASE AND DTIC DROLS MATERIALS IAC (CIAC, HTMIAC, MIAC, MMCIAC) AND MATERIALS RELATED IAC (MTIAC, NTIAC) DATABASES**
  - **TECHNICAL PERSONNEL REVIEWED INTERMEDIATE RESULTS AND ITERATED ON SEARCH TERMS TO IMPROVE QUALITY AND NUMBER OF SEARCH "HITS" ACHIEVED**
  - **ASSEMBLED SEARCH RESULTS AND TRANSMITTED PRODUCT TO ARL/MAMB**

# **SUMMARY OF DATA COLLECTED BY MMCIAC**

- **A LISTING OF BIBLIOGRAPHIC DATA ON SiC/Mg COMPOSITES  
WAS PREPARED**
  - **Technical papers, reports, books, and other documents**
  - **Bibliographic reference [title, author(s), corporate author(s),  
publication, identifying number(s), page(s), date(s), etc.],  
abstract, descriptors/identifiers/subject terms, supplementary  
notes**

# **RESULTS OF DATA ANALYSIS**

- **FINDINGS RESULTING FROM ANALYSIS OF THE BIBLIOGRAPHIC DATA ON SiC/Mg COLLECTED BY MMCIAC:**
  - Only a small amount of work has been conducted on this MMC class
- **SUMMARY OF TECHNICAL RECOMMENDATIONS FOUND IN THE BIBLIOGRAPHY:**
  - Further research on this MMC class is needed



## CONSEQUENCES

- THE SEARCH WAS "INTRINSICALLY VERY VALUABLE" TO THE REQUESTER



## **RELEVANCE TO OTHER USERS**

- **REQUESTING SIMILAR BIBLIOGRAPHIC SEARCHES BY MMCIAC OR OTHER MATERIALS AND MATERIALS RELATED IACS SHOULD BE A FIRST STEP FOR ALL RESEARCH AND DEVELOPMENT EFFORTS POTENTIALLY INVOLVING MMC OR OTHER MATERIALS, TO IDENTIFY**
  - **Work already done or in progress**
  - **Work not done or in progress**
  - **Existing manufacturing and processing information**
  - **Existing properties data**
  - **Existing applications of material class**
  - **Other state-of-the-art items**

**NTIAC**

**CRITICAL DOD ADVANCED MATERIALS:  
SCIENTIFIC AND TECHNICAL INFORMATION  
ANALYSIS**

**Presented by**

**George A. Matzkanin  
NTIAC**

**Texas Research Institute Austin, Inc.  
Austin, Tx. 78746**

**Approved for Public Release: Distribution Unlimited**

**Prepared by: George A. Matzkanin**

**NTIAC - 1**

## CONTEXT

- THIS TASK ADDRESSES THE FOLLOWING DEFENSE SCIENCE AND TECHNOLOGY STRATEGY ELEMENTS:
  - S & T Thrust 7, Technology for Affordability
    - Task goals:
      - Enhance system reliability and maintainability
      - Reduce operating and maintenance costs
      - Integrate product and process development
  - Key Technology 7, Materials and Processes
    - Task goals:
      - Reduce materials processing cost
      - Characterize advanced materials for new systems
      - Improve the efficiency of synthesizing new materials

## **OBJECTIVES**

- **FOCUS OF NTIAC TASK**
  - **Collection and Analysis of information and data relevant to advanced materials and NDE**
  - **Development of materials technology and NDE databases on advanced materials development and characterization**
  - **Assist in development of Tri-Service Reliance in advanced materials and NDE technologies**

## METHODOLOGY

- REVIEW JOINT DIRECTORS OF LABORATORIES TECHNOLOGY PANEL FOR ADVANCED MATERIALS (TPAM) PROGRAM PLANS AND DESCRIPTIONS
- DEVELOP A DATABASE AND METHODOLOGY TO GATHER NDE-RELATED TPAM INFORMATION IN A RAPIDLY ACCESSIBLE, EFFICIENT, AND USER-FRIENDLY WAY COMPATIBLE WITH OTHER NTIAC DATABASES
- CROSS-CORRELATE THE TPAM INFORMATION WITH INFORMATION ON OTHER GOVERNMENT (DOC, DOE, DOT, NASA, ETC.) AND INDUSTRIAL EFFORTS IN NDE OF ADVANCED MATERIALS

Prepared by: George A. Matzkanin

NTIAC - 4

## **SUMMARY OF DATA**

- **INFORMATION COLLECTED FROM TPAM SUB-PANEL AM-9, NDI/E TECHNOLOGY ON:**
  - **Advanced materials and process development**
  - **Manufacturing**
  - **In-service performance**
  - **Integrity/life monitoring**
- **CROSS-CORRELATION WITH GOVERNMENT INFORMATION COLLECTED FROM SUMMARY REPORT FOR 1993 MEETING OF THE COMMITTEE ON MATERIALS (COMAT) NDE TASK GROUP**
- **INDUSTRY INFORMATION COLLECTED FROM NTIAC DATABASE AND WORK IN-PROGRESS FILES**

## RESULTS

- TRI-SERVICE RELIANCE NDE GOALS FOCUS ON ENHANCED MATERIALS AND PROCESSING DEVELOPMENT, AND LOWER OPERATIONAL AND MAINTENANCE COSTS FOR WEAPON SYSTEMS
- DEVELOPMENT OF A COMPREHENSIVE INFORMATION DATABASE TO PROVIDE A BASIS FOR TRI-SERVICE RELIANCE EFFORTS IN NDE OF ADVANCED MATERIALS, TO AVOID DUPLICATION OF TECHNOLOGY PROGRAMS, AND TO IDENTIFY TECHNOLOGY GAPS

Prepared by: George A. Matzkanin

NTIAC - 6

## **CONSEQUENCES/BENEFITS**

- **REDUCTION OF COST TO PROCESS AND INSPECT ADVANCED COMPOSITE MATERIALS**
- **IMPROVED EFFICIENCY OF HIP PROCESSING OF ADVANCED MATERIALS THROUGH INTEGRATION OF NDE TECHNOLOGIES**
- **INCREASED OPERATIONAL READINESS OF WEAPONS SYSTEMS AND OPERATIONAL COST SAVINGS AS A RESULT OF OVERALL ENHANCEMENT OF RELIABILITY AND MAINTAINABILITY**
- **VERIFICATION OF THE QUALITY OF ADVANCED MATERIALS SYSTEMS UNDER DEVELOPMENT**
- **RELIABLE LIFE EXTENSION OF AGING MILITARY HARDWARE AND WEAPONS SYSTEMS**



## RELEVANCE TO OTHER USERS

- INFORMATION DATABASE ON ADVANCED MATERIALS NDE PROGRAMS AND WORK IN PROGRESS WILL BE BENEFICIAL TO GOVERNMENT AGENCIES AND CONTRACTORS
- CONCURRENT ENGINEERING AND DESIGN FOR INSPECTABILITY WILL BENEFIT FROM THIS STUDY AND RESULT IN OVERALL PRODUCTION COST SAVINGS
- THE NDE INFORMATION DATABASE AND CROSS-CORRELATION EFFORTS WILL FORM A PROTOTYPE FOR A LARGER, FULLY ENCOMPASSING TPAM DATABASE

Prepared by: George A. Matzkanin

NTIAC - 8

**NTIAC**

**QUANTITATIVE NONDESTRUCTIVE  
EVALUATION (NDE) DATA BOOK**

**Presented by**

**George A. Matzkanin**

**NTIAC**

**Texas Research Institute Austin, Inc.**

**Austin, Tx. 78746**

**Approved for Public Release; Distribution Unlimited**

**Prepared by: George A. Matzkanin**

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## CONTEXT

- THIS TASK ADDRESSES THE FOLLOWING DEFENSE SCIENCE AND TECHNOLOGY STRATEGY ELEMENTS:
  - S & T Thrust 7, Technology for Affordability
    - o Task goals: Reduce life-cycle costs; improve work flow scheduling; optimize system performance
  - Key Technology 10, Design Automation
    - o Task goals: Enhance effectiveness of systems design; provide a quantitative basis for computer-aided design

## OBJECTIVES

- FOCUS OF NTIAC TASK
  - Consolidate NDE engineering, inspection reliability, and application data into a single source, in a uniform format, to provide an engineering reference for design, maintenance, life-cycle management, and life extension
- RELATIONSHIP TO DEFENSE S & T STRATEGY
  - Reduce life cycle costs to achieve significant performance and affordability improvements
  - Reduce product development time by providing a quantitative basis for computer-aided design

## **METHODOLOGY**

- **COLLECT, ORGANIZE, ANALYZE, AND CATALOG DATA GENERATED AND DOCUMENTED IN VARIOUS FORMS FOR A NUMBER OF GOVERNMENT AGENCIES**
- **ORGANIZE NDE ENGINEERING DATA TO PROVIDE RAPID ACCESS OF SALIENT INFORMATION TO A VARIETY OF POTENTIAL USERS**
- **PHASE I PROVIDES AN INTRODUCTION AND BASELINE REFERENCE FOR COMMON ENGINEERING MATERIAL, SIMPLE SHAPES, AND GENERAL INDUSTRY ENVIRONMENTAL CONDITIONS**

Prepared by: George A. Matzkanin

NTIAC - 4

## **SUMMARY OF DATA**

- **INFORMATION COLLECTED FROM EXISTING AIR FORCE AND NASA ENGINE COMPONENT INSPECTION DATA**
- **DATA PROCESSED ELECTRONICALLY AND PRESENTED IN BOTH GRAPHICAL AND TABULAR FORM USING ESTABLISHED ANALYTICAL METHODS**
- **DATA ACQUIRED FROM APPROXIMATELY 15,000 MEASUREMENTS/OBSERVATIONS FROM LIQUID PENETRANT, ULTRASONIC, X-RADIOGRAPHY, EDDY CURRENT, AND MAGNETIC PARTICLE NDE METHODS**

## **RESULTS**

- **ESTABLISH STANDARD PROCEDURES FOR DETERMINING THE PROBABILITY OF DETECTING FLAWS OF VARIOUS SIZES IN COMPONENTS**
- **CATALOG PROBABILITY OF DETECTION (POD) CURVES FOR ASSESSING THE CAPABILITY OF NDE MEASUREMENT PROCEDURES**
- **PROVIDE A QUANTITATIVE BASIS FOR VALIDATING AND COMPARING NDE PROCEDURES**

Prepared by: George A. Matzkanin

NTIAC - 6

## **CONSEQUENCES/BENEFITS**

- **IMPROVED LIFE-CYCLE MANAGEMENT**
- **ESTABLISH A QUANTITATIVE BASIS FOR RETIREMENT FOR CAUSE**
- **ENHANCE SYSTEM RELIABILITY**
- **REDUCE DESIGN AND PRODUCTION COSTS**
- **SAVE ON MAINTENANCE COST**
- **REDUCE SYSTEM ACQUISITION TIME**



## RELEVANCE TO OTHER USERS

- LIFE EXTENSION OF AGING SYSTEMS
  - NASA
  - Air Force
  - Federal Aviation Administration
  - Federal Highway Administration
- QUANTIFY PROFICIENCY OF INSPECTORS

## ENERGY STORAGE



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# **ROCKET MOTOR MANUAL: ONE OF CPIA'S STANDARD MANUALS DIRECTED TO THE KEY DoD TECHNOLOGY ON ENERGY STORAGE**

**Prepared by**

**Thomas W. Christian  
Chemical Propulsion Information Agency (CPIA)  
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10630 Little Patuxent Parkway, Suite 202  
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**Approved for Public Release: Distribution Unlimited**



# CPIA CORE TECHNICAL PRODUCTS

- LITERATURE SEARCHES
- CHEMICAL PROPULSION TECHNOLOGY REVIEWS
- SELECTED PAPERS
- PROPULSION MANUALS
- CHEMICAL PROPULSION ABSTRACTS
- NEWSLETTER
- TECHNOLOGY BRIEFINGS
- CONTRACTS LIST
- ACRONYMS LIST
- JANNAF TECHNICAL MEETING AND WORKSHOP PROCEEDINGS

Prepared by: T. W. Christian

CPIA-2

DLB 1091



## PROPULSION MANUALS

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	<u>UNITS</u>	<u>UNITS/YR</u>
● M1 ROCKET MOTOR	271	4.5
● M2 SOLID PROPELLANT	198	2.1
● M3 SOLID PROPELLANT INGREDIENTS	85	7.5
● M4 LIQUID PROPELLANT	31	1.0
● M5 LIQUID PROPELLANT ENGINE	122	2.2
● M6 AIRBREATHING PROPULSION	12	0.6
● M7 LIQUID ROCKET ENGINE STATIC TEST FACILITIES (ESTABLISHED 1987)	120	1.0
● M8 SOLID ROCKET MOTOR STATIC TEST FACILITIES (ESTABLISHED 1991)	44	7.0



## CONTEXT

---

- BROAD OBJECTIVE OF THE ENERGY STORAGE TECHNOLOGY APPLIED TO MISSILES, SPACE, AND GUN SYSTEMS
  - Develop Insensitive, Powerful Energetic Materials (Ref: DoD Key Technologies Plan)
- SUBSET OF ENERGY STORAGE TECHNOLOGY
  - Develop and Demonstrate High Energy, High Density, Insensitive, Minimum Smoke Propulsion Systems (Ref: ODDR&E Aerospace Propulsion and Power S&T Review and the Joint Directors of Laboratories, Technical Panel for Conventional Air/Surface Weaponry)
- MILITARY PAYOFFS
  - Reduced Platform Detectability
  - Reduced Weapon Vulnerability (Insensitive Munitions)
  - Reduced Environmental Impact
  - Reduced Propellant Exhaust Toxicity
  - Improved Weapons Range/Velocity



## BASIC CPIA INFORMATION PRODUCT

- CPIA INFORMATION PRODUCT FOCUS
  - Tasks
    - Provide engineering drawings, descriptions, and ballistic data on rocket motors and their components
  - Requestors
    - Military services, NASA, and industry
  - Assistance Form
    - Preparation and maintenance of manual data sheets on new rocket motors



## CPIA METHODOLOGY

- METHODOLOGY USED TO PRODUCE MANUAL UNITS
  - Data Collection
    - Questionnaires, technical reports, personal contacts, and manufactures' data sheets.
  - Data Analysis
    - Selection, data reduction, verification, and conversion
  - Data Synthesis
    - Run performance codes to determine theoretical performances and exhaust species
- APPROACH
  - Uniqueness
    - Use of established JANNAF and industrial resources to collect the required raw data
  - Existing information CPIA used
    - JANNAF meeting and workshop proceedings, technical reports, and AF Gray Book





# ROCKET MOTOR MANUAL (CPIA/M1)

Page 1  
CPIA/M1

UNCLASSIFIED

April 1983

Unit No. 580  
146-KS-195 720  
(146-KS-46,000)  
IUS SRM 1

Manufacturer: United Technologies/Chemical Systems Division, Sunnyvale, CA  
System Prime Contractor:  
Sponsoring Agency: Air Force Space Division, Los Angeles, CA  
Application: Upper Stage Motor for Titan 340 and Shuttle Space Transportation System

## PRINCIPAL DATA

DOT-IOC/Military Explosives Hazard Class: Motor;  
Igniter:  
Propellant:

Overall Length: 3.13 m (124 in.)  
Maximum Diameter: 2.36 m (92 in.)  
Operational Temperature Limits:  
Storage Temperature Limits:  
Acceleration Limits:  
Mass Properties:  
case assembly  
nozzle assembly  
igniter and S/A assembly  
internal insulation/liner  
external insulation  
other inert parts  
total inert mass  
ordnance train  
propellant mass,  $m_p$   
motor gross mass  
Propellant Mass Fraction:  
Propellant Volume Fraction:  
Center of Gravity:  
(At Altitude)

BALLISTIC PERFORMANCE (289 K (60°F))

Burning Time 146 s  
Action Time  
Maximum Pressure,  $P_{max}$ : 6 109 kPa (886 psia)  
Average Pressure 4 489 kPa (651 psia)  
Maximum Thrust,  $F_{max}$ : 267.78 kN (60,200 lbf)  
Average Thrust 195.72 kN (44,000 lbf)  
Total Impulse 28.11 x 10<sup>6</sup> N·s (6.32 x 10<sup>6</sup> lbf-sec)  
Propellant Specific Impulse,  $I_{sp}$ : 2 898 N·s/kg (295.5 lbf-sec/lbm)

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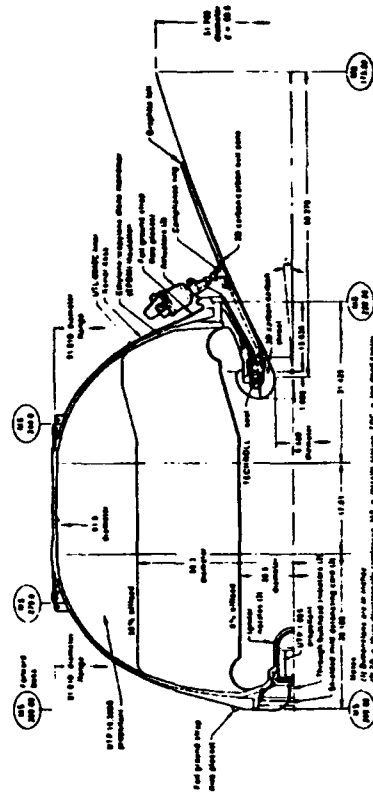
UNCLASSIFIED

Published by The Johns Hopkins University Applied Physics Laboratory, Chemical Propulsion Information Agency (CPPIA), Johns Hopkins Road, Laurel, MD 20785

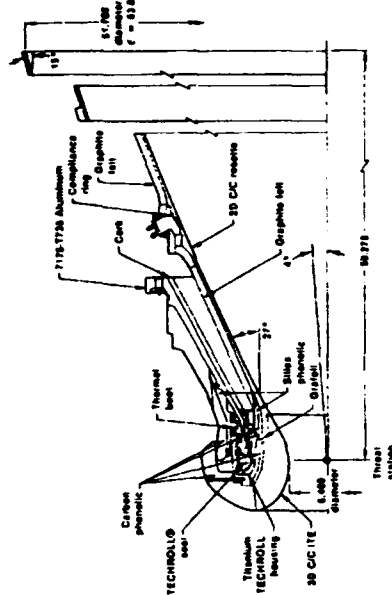
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April 1983

Unit No. 580  
IUS SRM 1



F-01. SRM-1 Motor Assembly



F-02. SRM-1 Nozzle Design

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Published by The Johns Hopkins University Applied Physics Laboratory, Chemical Propulsion Information Agency (CPPIA), Johns Hopkins Road, Laurel, MD 20785



## SUMMARY OF DATA

---

- DATA COLLECTED

- Data and information collected during the performance of this task:
  - Motor designations, engineering dimensional data of the motors and their components, ballistic performance data, compositional and ballistic data of the motor propellants, manufacturing processes, safety and sensitivity data.
- Interesting characteristics common to the data:
  - Higher motor performance tends to be associated with higher motor vulnerability



## RESULTS OF DATA ANALYSIS

- FINDINGS RESULTING FROM THE ANALYSIS OF DATA COLLECTED BY CPIA
  - Significant motor performance improvements have been realized over the past 20 years.



# CONSEQUENCES

---

- RESULT OF PRODUCING AND MAINTAINING THE CPIA M/1 MANUAL
  - Values/Benefits
    - Over the past three years, over 84 Government and industrial organizations have paid approximately \$13,000/y to receive the new units for this manual.
    - Military services have instant source of on-shelf rocket motors
    - Cost-savings realized by having motor data in single location
  - Changes in DoD operations, plans, or procedures as a direct result of these manuals
    - Without the manual, DoD, the military services, and industry would be required to seek the data from multiple sources, resulting in delays, incomplete and/or inaccurate data, and increase use of manpower.



## RELEVANCE TO OTHER USERS

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- RELATED OR ANALOGUE SUBSTANTIVE PROBLEMS FOR WHICH THE CPIA SOLID ROCKET MOTOR MANUAL WOULD BE RELEVANT
  - Gas generators that could be used in the inflation of automobile safety bags
- RELATED OR ANALOGOUS PROBLEMS FOR WHICH THE CPIA MANUAL WOULD BE RELEVANT BECAUSE OF THE DATA OR METHODOLOGY USED
  - Standardized formats for technical handbooks
  - Storage and disposal of rocket motors

# **PROPULSION AND ENERGY CONVERSION**



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**EXPLOSIVE INGREDIENTS SOURCES  
DATABASE (EISD):  
A CIA TECHNICAL AREA TASK APPLIED TO  
NAVAL SURFACE SEA CONTROL**

**Prepared by**

**Thomas W. Christian  
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Columbia, MD 21044-3200**

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## CONTEXT

- BROAD OBJECTIVE OF THE NAVAL SURFACE SEA CONTROL PLAN
  - Maintain and develop weapons that will ensure the fighting superiority of U.S. Navy Surface Forces
- SUBSET OF THE NAVAL SURFACE SEA CONTROL PLAN
  - Maintain the resources to produce explosives used in the U.S. fleet
- MILITARY PAYOFFS
  - Maintain the U.S. fleet as a viable military deterrent in theater combats

Prepared by: T. W. Christian

CPIA-2

DLR 10/93





# CPIA TASK INFORMATION PRODUCT

- CPIA TASK PRODUCT FOCUS

- Task

- Develop and maintain a database linking manufacturing sources and problems of explosive ingredient with fielded explosive formulations

- Requester

- Naval Surface Warfare Center Indian Head

- Form

- Developed a PC-based database and prepared and delivered a user guide to the sponsor

Prepared by: T. W. Christian

CPIA-3

DLB 1003



# CPIA METHODOLOGY

- METHODOLOGY USED TO PERFORM WORK
  - Data Collection
    - Collected the Navy explosive formulations, identified the various ingredients and manufacturers, and contacted the manufacturers as to their producible capability. Also reviewed journal articles and current news articles that related to changes to a manufacturers capability to product a specific ingredient.
- APPROACH
  - Uniqueness
    - Knowledge of explosive formulations and ingredient suppliers
  - Existing information
    - Chem Sources - USA, Chem Sources - International, Chemcyclopedia, Chemical Week Buyer's Guide (U.S., Japanese editions), SRI International - U.S., Canadian, Western European Chemical Producers

Prepared by: T. W. Christian

CPIA-4

DIA 1003



# EISD STRUCTURE

### 1. View Ingredient Summary Data

## 2. View Explosive Formulations Data

**9. View Ingredients vs. Formulations Data -**

#### 4. Print an Ingredient Status chart

### S. Print an Explosive Formulation Listing

#### 6. Print an ingredient v.s. Formulation Listing

## 7. Consult the Ingredients Index

### 3. Consult the Formulations Index

## EXPLOSIVES FORMULATIONS DATA

NAME: Composition A-3 (aluminized) MIL SPEC:

**SERVICE: Navy**

STATUS PER OP 3613:

STATUS PER OP 3613:

[illegible]

### INGREDIENTS SUMMARY DATA

**INGREDIENT:** Aluminum

## SOURCES

#1: Valmet, Inc.	\$	/lb	lb/yr
#2: Alcan-Toyo America, Inc.	\$	/lb	lb/yr
#3: Aluminum Co. of America	\$	/lb	lb/yr
#4: Reynolds Metals Co.	\$	/lb	lb/yr

**INGREDIENTS AVAILABILITY:**

NO	A critical chemical (i.e., has significant supply/availability problems)
NO	Only one domestic source (produced in U.S. or Canada)
NO	Produced only by foreign source(s) (produced outside the U.S. or Canada)
NO	Current or projected use exceeds current or planned production capacity
NO	Available material does not meet specification requirements
NO	Ingredient toxicity or environmental problems that jeopardize future use
NO	Raw material problems (produced by foreign source(s) and no domestic substitute raw materials are available)

### INGREDIENTS AND EXPLOSIVE FORMULATIONS DATA

**INGREDIENT: Aluminum**

Composition: A-3 (aluminized)

11-6  
11BX-1

LOVE

Minol II

PB.XC-117 PB.XN-1

PBXN-103

PBXN-109 PBXN-111

PBXW-114 Type II  
PBXW-124  
T-1000-1000

PLIX-W.125 Tritonal

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## SUMMARY OF DATA

- DATA COLLECTED

- Data and information collected during the performance of this task:

- Identified foreign and U.S. sources of the explosive ingredients, applicable military specifications, DoT hazard classifications, storage requirements, environmental and handling concerns, and commercial uses of the ingredients

- Interesting characteristics common to the data

- Many of the explosive ingredients are used in explosives and rocket propellant formulations of the other military services.

Prepared by: T. W. Christian

CPA-5

DLR 10/93



## RESULTS OF DATA ANALYSIS

---

- FINDINGS RESULTING FROM THE ANALYSIS OF DATA COLLECTED BY CPIA
  - Many critical explosive ingredients are either supplied by foreign sources or single U.S. sources.
- SUMMARY OF TECHNICAL RECOMMENDATIONS
  - Do not rely on foreign or sole sources for these ingredients. Seek either alternative ingredients or ingredient sources.



# CONSEQUENCES

- DEVELOPING AND MAINTAINING DATABASE
  - Values/Benefits
    - Maintain the U.S. Navy capability to provide fleet explosives in case of full militarization
  - Changes in DoD Operations, Plans, or Procedures as a Direct Result of the Database
    - By being aware of the potential shortage of a particular explosive ingredient, the U.S. Navy seeks alternative suppliers, thus saving the in-house cost of producing the ingredient, or saving the high cost of a rush production of the ingredient by a commercial company, or saving the cost of requalifying a supplier.

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CPIA-7

DLR 1091



## RELEVANCE TO OTHER USERS

- RELATED OR ANALOGOUS SUBSTANTIVE PROBLEMS FOR WHICH THE CPIA PRODUCT WOULD BE RELEVANT
  - Database could be expanded to include ingredients in U.S. Army explosives and ingredients in solid rocket propellants.
- RELATED OR ANALOGOUS PROBLEMS FOR WHICH THE CPIA PRODUCT WOULD BE RELEVANT BECAUSE OF THE DATA OR METHODOLOGY USED
  - Use of standardized database for other materials availability



**CHEMICAL PROPULSION TECHNOLOGY REVIEWS:  
A SERIES OF CPIA CORE PRODUCTS DIRECTED  
TO THE KEY DoD TECHNOLOGY ON  
PROPULSION AND ENERGY CONVERSION**

**Prepared by**

**Thomas W. Christian**  
**Chemical Propulsion Information Agency (CPIA)**  
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# CPIA CORE TECHNICAL PRODUCTS

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- SELECTED PAPERS
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- CHEMICAL PROPULSION ABSTRACTS
- NEWSLETTER
- TECHNOLOGY BRIEFINGS
- CONTRACTS LIST
- ACRONYMS LIST
- JANNAF TECHNICAL MEETING AND WORKSHOP PROCEEDINGS

Prepared by: T. W. Christian

CPIA-2

DLR 1093





# CPE REPORTS RELATED TO PROPULSION AND ENERGY CONVERSION TECHNOLOGY

- GFYS 1991-1993
  - New Solid Propellant Processing Techniques
  - AN Propellants
  - LO<sub>2</sub>/LH<sub>2</sub> Liquid Rocket Engine Cycles
  - Gelled Propellants Technology
  - Insensitive Munitions Motor Components
  - High-Energy Oxidizers as HMX Replacements

Prepared by: T. W. Christian

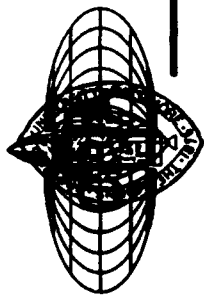
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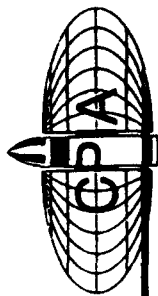


## CONTEXT

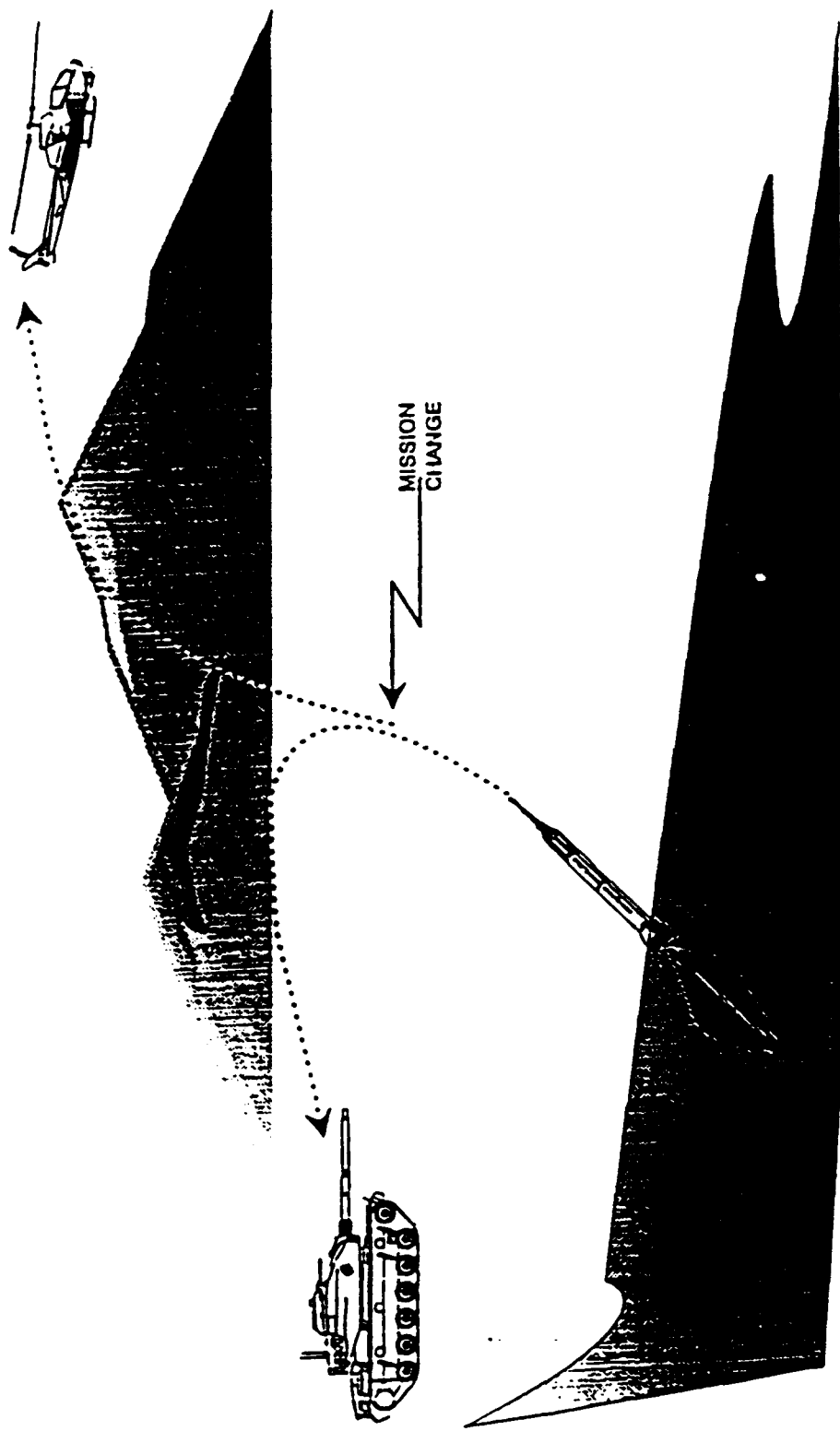
- A BROAD OBJECTIVE OF THE PROPULSION AND ENERGY CONVERSION TECHNOLOGY PLAN APPLIED TO MISSILE, SPACE, AND AEROSPACE VEHICLES IS TO:
  - Double Propulsion Capability by 2010 (Ref: JANNAF Missile and Space Propulsion Plan)
- SUBSET OF THE PROPULSION AND ENERGY CONVERSION TECHNOLOGY PLAN:
  - Apply bipropellant gel propellant technology applied to smart propulsion (Ref: ODDR&E Aerospace Propulsion and Power Science and Technology Review)
- MILITARY PAYOFFS
  - Provide target selection flexibility
  - Extend sphere of engagement and missile range
  - Enhance end-game capability



# SMART PROPULSION



## DIVERT TO A HIGHER VALUE TARGET



Prepared by: T. W. Christian



## BASIC CIA INFORMATION PRODUCT

- CIA INFORMATION PRODUCT FOCUS
  - Task
    - Summarize and assess the U.S. effort to develop insensitive bipropellant gels that can be applied to smart propulsion for weapons systems
  - Requesters
    - Military services and the U.S. propulsion community
  - Assistance Form
    - Produced a technology review

Prepared by: T. W. Christian

CPIA-5

DLB 109A



# CPIA METHODOLOGY

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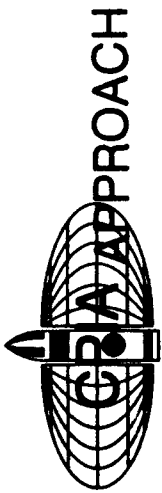
- METHODOLOGY USED TO PERFORM WORK

- Data Collection

- JANNAF, JDL, and ODDR&E Propulsion Science and Technology Reviews guide topic selection so that selected topics are germane to current propulsion technology problems. We use our Propulsion Information Retrieval System (PIRS) and DTIC databases to identify relevant documents; other data sources include personal contacts of in-house technical staff, external commercial or academic sources where appropriate, and corporate or organizational sources.

- Data Analysis

- As a result of the literature searches, documents are screened and selected based upon relevancy and the author's knowledge of the subject. The author then prepares an outline of the article for approval. Thereafter, the article is drafted, edited, and submitted for external peer review. The reviewers comments are assessed and, if appropriate, they are incorporated into the article.



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-- Uniqueness

- o Systematic selection of topics and a standard article preparation procedure
  - o Use of unique mix of capabilities of CPIA technical staff in information science and propulsion technology
- Existing information CPIA used
- o JANNAF technical papers and external reports

Prepared by: T. W. Christian

CPIA-7

121.B 10/93



## SUMMARY OF DATA

- DATA COLLECTED

- Data and information collected during the performance of this task:

- Data and description of system hardware - feed systems, pressurization, systems pumps, injectors, tankage, and safety aspects
- The performance, combustion characteristics, physical and rheological properties of both fuel and oxidizer gels
- Missions suitable for application of gel technology

- Interesting characteristics common to the data:

- Bipropellant gels fall into the class of non-Newtonian fluids with time/temperature-dependent properties which must be considered in developing an effective fuel/oxidizer delivery system. Also, many of the gels are carcinogenic.

Prepared by: T. W. Christian

CPIA-8

12110 10/93





# RESULTS OF DATA ANALYSIS

- FINDINGS RESULTING FROM THE ANALYSIS OF DATA COLLECTED BY CIA
  - The bipropellant gels are nonreactive until mixed together, thus they are good candidates for insensitive munitions that meet MIL-STD 2105A. The gels can be metered, providing throttability and increased range and end-game capability for the missile systems.
- SUMMARY OF TECHNICAL RECOMMENDATIONS
  - The toxicity of the candidate gels must be resolved before they can be considered viable propellants

Prepared by: T. W. Christian

CPIA-9

DIJ 1093





## CONSEQUENCES

- RESULT OF PRODUCING THESE SERIES OF TECHNOLOGY REVIEWS:
  - Values/Benefits
    - Over the past three years, over 100 Government and industrial organizations have subscribed to these reviews at a cost of approximately \$45,000/y
    - The reviews permit DoD/military program managers access to overviews of relevant propulsion technology issues

Prepared by: T. W. Christian

CPIA-10

DIJ 1091



## RELEVANCE TO OTHER USERS

- RELATED OR ANALOGOUS SUBSTANTIVE PROBLEMS FOR WHICH THE CPIA PRODUCT WOULD BE RELEVANT
  - Bipropellant gels can be applied to high thrust liquid rocket engines. The fuel gels can be applied to airbreathing propulsion systems.
- RELATED OR ANALOGOUS PROBLEMS FOR WHICH THE CPIA PRODUCT WOULD BE RELEVANT BECAUSE OF THE DATA OR METHODOLOGY USED
  - Propulsion technology assessment papers

Prepared by: T. W. Christian

CPIA-11

DI.R 10'93

# DESIGN AUTOMATION



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# **CREW SYSTEM ERGONOMICS INFORMATION ANALYSIS CENTER (CSERIAC) PRODUCTS & SERVICES**

**Presented by**

**Donald Dreesbach  
AL/CFH/CSERIAC**

**Bldg. 248**

**2255 H Street**

**Wright-Patterson AFB, OH 45433-7022**



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## **ADVANCED HUMAN SYSTEM INTERFACE DESIGN IN CONTROL ROOMS**

- **Task Overview & Project History**
- **Shortcomings of Scientific and Technical Information**
- **Subject Matter Reviewed**
- **CSERIAC's Review and Analysis Services**
- **Results of CSERIAC's Efforts**
- **Consequences of CSERIAC's Efforts**
- **Applications**



## PROJECT OVERVIEW AND HISTORY

- CSERIAC and the Nuclear Regulatory Commission
  - » Human Systems Interface Design Review Guideline (NUREG/CR-5908)
- Project History
  - » Document review process



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## SHORTCOMINGS OF SCIENTIFIC AND TECHNICAL INFORMATION

- Shortcomings of Scientific and Technical Information,  
Control Rooms Revisited:
  - » Changing technology
  - » Research gaps
  - » Advances in human factors research





## **SUBJECT MATTER REVIEWED BY CSERIAC**

- **Human factors and control room design**
  - » **Display and Control Technologies**
  - » **Automation, Intelligent Aids, and Human Error**
  - » **Nuclear Power Plant Control Room Integration**



## CSERIAC REVIEW & ANALYSIS SERVICES

- Purpose
- Procedure
- Content
- Synthesis



## **RESULTS OF CSERIAC's EFFORTS**

- **Reviews & Analyses Final Reports:**
  - » **Display and Control Technologies**
  - » **Automation, Intelligent Aids, and Human Error**
  - » **Nuclear Power Plant Control Room Integration**



## CONSEQUENCES OF CSERIAC's EFFORTS

- Project Evaluation
- Further Study
- Update:
  - » Advanced Human Systems Interface Design Review Guideline
  - » The design of future control facilities





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## APPLICATIONS

- **Benefits to the design of control facilities:**
  - » Extensive review of display control technologies
  - » Expanding upon research and applications of human factors in automation
  - » Expanding upon research and applications of artificial intelligence
  - » Expanding upon research in the area of human error
  - » Expanding upon research in the area of system integration



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## COMPUTER-AIDED SYSTEMS HUMAN ENGINEERING (CASHE)

- Definition
- Capabilities
- Justification
- CASHE Interface
- Results of CSERIAC's Efforts
- Consequences of CSERIAC's Efforts



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## COMPUTER-AIDED SYSTEMS HUMAN ENGINEERING (CASHE): DEFINED

- An interactive multimedia computer database for crew system design utilizing the data, figures, and tables, contained in:
  - The Engineering Data Compendium
  - Military Standard 1472 D





## **CAPABILITIES OF CASHE**

- **Prototyping the human factor**
  - CASHE is the presentation of Human Factors information in a flexible and interactive environment:
    - » Allows the manipulation of research and design data in real-time
    - » Provides an experiential medium to simulate human performance and perception



## **JUSTIFICATION FOR THE DEVELOPMENT OF CASHE**

- **Ergonomics and System Designers**
  - » Volume of material
  - » Lack of a central source of information
  - » Limited time and resources to acquire and analyze data
  - » Terminology and concepts foreign to engineering
  - » Lack of data specific to their project



## CASHE INTERFACE

- **Bookshelf**
- **File Management**
- **File Viewers**
- **Visualization Tools**
  - Perception and Performance Prototyper
  - Data Viewer
    - » Definition
    - » Acquisition
    - » Transformation
    - » Presentation



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## RESULTS OF CSERIAC's EFFORTS

- CSERIAC provided the integration of many technologies and subject-matter expertise which supported:
  - » The acquisition and transformation of all graphics
  - » The development of program engines
  - » The development of test benches
  - » The development of the user manual
  - » Overall project integration resulting in a user-friendly product



## CONSEQUENCES OF CSERIAC's EFFORTS

- CSERIAC provided an environment which streamlined CASHE development
  - Task Management
    - » Contract Support
    - » Sub-contractor management
  - Contact with Subject-Matter Experts
  - Data acquisition



## CASHE APPLICATIONS

- CASHE is not limited to one particular discipline or environment. It is useful to not only designers but also researchers and human factors practitioners in the DoD, Industry, and Academia.

**RAPID PROTOTYPING  
MTIAC STATE-OF-THE-ART-REPORT**

**Prepared by**

**Michal Safar  
Manufacturing Technology Information Analysis Center  
IIT Research Institute  
10 West 35th Street  
Chicago, IL 60616**

**Approved for Public Release: Distribution Unlimited**

# **MTIAC RAPID PROTOTYPING DOD KEY TECHNOLOGY - DESIGN AUTOMATION**

- **DESIGN AUTOMATION COMPONENTS**
  - **Computer-Aided Design**
  - **Concurrent Engineering (Product & Process Development)**
  - **Simulation and Modeling**
- **DESIGN AUTOMATION GOALS AND OBJECTIVES**
  - **Design Tool for Performance, Manufacturability and Life Cycle Issues**
  - **Transportable Product Descriptions**
  - **Functional and Feature Based Design**
  - **High Fidelity Product Visualization**
  - **Product Performance - Supportability Interaction**



# **MTIAC RAPID PROTOTYPING DOD KEY TECHNOLOGY - DESIGN AUTOMATION**

- **KEY TECHNOLOGY - DESIGN AUTOMATION**
  - **Computer-Aided Design**
  - \* **Concurrent Engineering (Product & Process Development)**
  - **Simulation and Modeling**
  
- **APPROACH - EVOLUTIONARY PRODUCT RESPONSE**
  - **1989 - First User Inquiries - First Appearance of Technology**
  - **1990 - Bibliographies - Initial Development**
  - **1991 - Technology Assessment - Technology Explosion**
  - **1993 - State-of-the-Art Report - Technology Established**

# **MTIAC RAPID PROTOTYPING DOD KEY TECHNOLOGY - DESIGN AUTOMATION**

- **MTIAC/IAC METHODOLOGY**
  - **Data Collection - Technical Conferences, Surveys, Literature**
  - **Data Analysis - Standardize System Features**
  - **Data Synthesis - Comparison and Evaluation**
  
- **APPROACH - TECHNOLOGY TRACKING**
  - **First stage - Identify all material**
  - **Early stage - Organize material, identify issues & trends**
  - **Middle stage - Direct contact with developers and researchers**
  - **Later stage - Track mature technology**

# **MTIAC RAPID PROTOTYPING DOD KEY TECHNOLOGY - DESIGN AUTOMATION**

- **RAPID PROTOTYPING TECHNICAL DATA**

- **Software Requirements (What Do I Need to Implement?)**
  - CAD Data Conversion
  - .STL File Format
- **Systems Information (What Is Available?)**
  - Commercially available
  - Under research
- **Applications Information (Who Has It and Where Can I Get It?)**
  - Industry applications
  - Source Information

# **MTIAC RAPID PROTOTYPING DOD KEY TECHNOLOGY - DESIGN AUTOMATION**

- **FINDINGS**
  - Technology Very New and Developed Quickly
  - Newly Developed Systems Not Well Described or Understood
  - Design Automation Application - Real & Potential
- **RECOMMENDATIONS**
  - Evaluate Software Requirements
  - Evaluate Alternative Prototyping Systems
  - Evaluate Cost Drivers
    - o Equipment
    - o Software
    - o Personnel

# **MTIAC RAPID PROTOTYPING DOD KEY TECHNOLOGY - DESIGN AUTOMATION**

- **DESIGN AUTOMATION KEY TECHNOLOGY GOALS**
  - **High fidelity product visualization**
  - **Product and Process Definition**
    - o **Physical Implementation Prototyping**
- **TECHNOLOGY FOR AFFORDABILITY**
  - **Reduction in Time to Market**
  - **Early Detection of Design Flaws**
  - **Cost Reduction**
- **MTIAC PRODUCT BENEFITS**
  - **Evaluation Tool Available**
  - **Increased Technology Implementation**

# **MTIAC RAPID PROTOTYPING DOD KEY TECHNOLOGY - DESIGN AUTOMATION**

- **BROAD AUDIENCE**
  - Evolutionary Product Development
  - Ongoing User/Producer Input
- **TECHNICAL APPLICATIONS EVALUATIONS**
  - Standardized Evaluation Criteria
    - o Software requirements
    - o Equipment requirements
    - o Other considerations
  - Standardized Data Presentation
    - o Comparison charts
    - o Standardized data sheets

# HUMAN SYSTEM INTERFACES

# **IAC TASK**

- **WHAT**
  - **Resolve Issues Resulting from the use of two Different Test Methods to Evaluate Protective Clothing**
    - **Validate without Polyethylene Film Test**
    - **Correlate with and without Film Methods**
  - **Fill Critical Gaps in Database for Current and Developing Material Technologies**
  - **Determine the Effects of Wearing Suits Upon Levels of Protection Provided**
- **WHY**
  - **Improved Protective Capabilities Needed**
    - **Reduction in Heat Stress**
    - **Reduction in Logistical Support Requirements**
  - **More Sensitive Test Method Needed**
- **WHO**
  - **U.S. Army**



## **IAC METHODOLOGY**

- **PERFORM SIDE BY SIDE COMPARISONS OF TEST METHODS**
  - **Test Worn Suit Materials using both Methods**
- **ATTEMPT TO CORRELATE TEST RESULTS**

**EVALUATION OF LIGHTWEIGHT INTEGRATED SUIT  
TECHNOLOGIES (LIST) AND ASSOCIATED TEST  
METHODS**

**Prepared by**

**John M. Smith and James J. McNeely  
CBIAC  
Chemical Biological Information Analysis Center  
Battelle  
2113 Emmorton Park Road  
Edgewood, MD 21040**

**Approved for Public Release: Distribution Unlimited**

# **CONTEXT**

- **ADVANCED LAND COMBAT (S&T THRUST)**
  - **Rapid Force Deployment**
  - **Tactical Mobility**
  - **Quick Mission Accomplishment**
  - **Minimal Casualties Against Heavy Armor and Smart Weaponry**
- **NBC ENVIRONMENT LIKELY**
  - **Proliferation**
  - **Biotechnology Advances**
  - **Affects Battlefield Dynamics**
    - **Survivability**
    - **Performance Degradation**
    - **Support**

## **RESULTS**

- **WORN LIGHTWEIGHT SUIT MATERIALS SHOWN TO PROVIDE ADEQUATE LEVELS OF CHEMICAL AGENT RESISTANCE**
- **DATA GENERATED USING DIFFERENT METHODS COULD NOT BE CORRELATED**
- **"RELATIVE" RANKINGS OF SUIT MATERIALS FOUND TO BE SIGNIFICANTLY DIFFERENT DEPENDING UPON METHOD USED**
- **TESTING WITHOUT FILM FOUND TO BE MORE SENSITIVE AND A BETTER METHOD FOR QUANTIFYING THE EFFECTS OF WEAR**

## **CONSEQUENCES**

- **PROVIDED VALUABLE GUIDANCE FOR WEAR AND LOGISTICAL SUPPORT OF LIGHTWEIGHT CLOTHING DURING OPERATION DESERT STORM (ODS)**
- **WITHOUT PE FILM ADOPTED AS THE U.S. STANDARD SWATCH TEST METHOD FOR MATERIALS EVALUATION**
- **STANDARDIZED QUALITY CONTROL AND QUALITY ASSURANCE METHODS FOR EVALUATION OF CHEMICAL PROTECTIVE CLOTHING MATERIALS**
- **EVOLUTION OF JOINT SERVICES PROGRAM - JSLIST**

## **RELEVANCE TO OTHER USERS**

- **ORGANIZATIONS RESPONSIBLE FOR ESTABLISHING STANDARDS AND TEST METHODS FOR CHEMICAL PROTECTIVE CLOTHING (CPC)**
  - **ASTM**
  - **ISO**
- **TESTERS OF CPC**
- **USERS OF CPC**
  - **Hazmat Teams**
  - **Department of Transportation (DOT)**
  - **Department of Energy (DOE)**
  - **Manufacturers of Hazardous Chemicals**

**INTERACTIVE DECISION TRAINING SCENARIO FOR USN  
DAMAGE CONTROL AND CBR-D DECISION TRAINING**

**Prepared by**

**James J. McNeely  
CBIAC  
Chemical Biological Information Analysis Center  
Battelle  
2113 Emmorton Park Road  
Edgewood, MD 21040**

**Approved for Public Release: Distribution Unlimited**

## **CONTEXT**

- **SEA CONTROL AND TACTICAL NAVAL SURFACE FORCES**
  - **Naval Interdictions**
  - **Operate in Littoral Zones**
  - **Losses to a Minimum**
- **NBC ENVIRONMENT LIKELY**
  - **Proliferation**
  - **Increased use Scenarios**

**Prepared by: James J. McNeely**

**CBIAC - 2**



## **IAC TASK**

- **WHAT**
  - **Interactive Damage Control Scenario Presentation System (DECAID)**
- **WHY**
  - **Risk Management Essential in CBR Environments**
    - **Increased Burdens**
    - **Competing Demands**
  - **Training Shortfall -- Integration of CBR Defense with other Damage Control Functions**
- **WHO**
  - **U.S. Naval Training Systems Center**

# **IAC METHODOLOGY**

- **DEVELOP DAMAGE CONTROL DECISION TASKS AND RISK MANAGEMENT DILEMMAS**
- **DEVELOP DECAID SCENARIOS**
  - **Fire**
  - **Flood**
  - **Chemical Attack**
  - **Combinations**
- **DEVELOP DECAID RULE BASE USING INPUT FROM SUBJECT MATTER EXPERTS (SMES)**
- **DEVELOP INTERACTIVE DEMONSTRATION**
- **REVIEW BY NAVY USERS**

## **SUMMARY OF DATA**

- **DEVELOPED**
  - **Scenarios**
  - **Interface Features**
    - **Controls, Displays, etc**
  - **Rules**
    - **Firemen, crew, event**
  - **Software (Primarily in C)**
- **CONDUCTED DEMONSTRATIONS**

## **RESULTS**

- **SUCCESSFUL "6.2" DEMONSTRATION OF CONCEPT**
  - **Instructors of Navy Advance CBR Course**
  - **Surface Warfare Officer School**

## **CONSEQUENCE**

- **PRODUCT INTEGRATED INTO NAVY TRAINING COURSE**
- **USN PURSUING ADDITIONAL DEVELOPMENT**

**MEDTAG**  
**CONCEPT EVALUATION AND PROTOTYPE**  
**DEVELOPMENT PLAN**

**Prepared by**

**Clark Fortney and James J. McNeely**  
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**Chemical Biological Information Analysis Center**  
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**Approved for Public Release: Distribution Unlimited**

# **CONTEXT**

- **ADVANCED LAND COMBAT (S&T THRUST)**
  - **Rapid Force Deployment**
  - **Tactical Mobility**
  - **Quick Mission Accomplishment**
  - **Minimal Casualties Against Heavy Armor and Smart Weaponry**
- **NBC ENVIRONMENT LIKELY**
  - **Proliferation**
  - **Biotechnology Advances**
  - **Affects Battlefield Dynamics**
    - **Survivability**
    - **Performance Degradation**
    - **Support**

# IAC TASKS

- **WHAT**

- **Evaluate and Demonstrate the Technical Feasibility of the MEDTAG Concept**

- **WHY**

- **Problems Associated with Present Practice - The Field Medical Card (FMC)**

- **Rarely Implemented**

- **Too Slow**

- **Poor Data Quality -- Errors and Obliterations**

- **Need for Capability in CBW Environments and Extreme Weather Conditions**

- **Limitations Associated with Current Pilot Programs - Requirement for Interface Device -- Reader/Writer**

- **WHO**

- **U.S. Naval Health Research Center**



# **IAC METHODOLOGY**

- **REFINE REQUIREMENTS**
- **SELECT AND EVALUATE TECHNICAL ALTERNATIVES**
- **DEVELOP PROOF-OF-CONCEPT VERSION OF MEDTAG**
- **DEMONSTRATE BASIC TECHNICAL FEASIBILITY OF MEDTAG CONCEPT**
- **DEVELOP PLAN AND OPTIONS FOR MEDTAG**
  - **Miniaturization and Ruggedization**

## **RESULTS**

- **PROOF-OF-CONCEPT UNIT DESIGNED AND DEVELOPED**
- **PROOF-OF-CONCEPT DEMONSTRATED**
  - **Data Entry Time Reduced - Seconds Versus Minutes**
  - **Data Entry Accuracy Improved - Interactive Data Dictionary**
- **MINIATURIZATION AND RUGGEDIZATION PLANS DEVELOPED**

## **CONSEQUENCES**

- **DEVELOPMENT OF VIABLE APPROACH FOR IMPROVING BATTLEFIELD MEDICAL CARE**
- **POTENTIAL FOR INCREASED SURVIVABILITY OF MILITARY FORCES**

## **RELEVANCE TO OTHER USERS**

- **ALL SERVICES**
- **ALLIES**
- **CIVILIAN EMERGENCY MEDICAL SERVICES**



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## **ADVANCED HUMAN SYSTEM INTERFACE DESIGN IN CONTROL ROOMS**

- Task Overview & Project History
- Shortcomings of Scientific and Technical Information
- Subject Matter Reviewed
- CSERIAC's Review and Analysis Services
- Results of CSERIAC's Efforts
- Consequences of CSERIAC's Efforts
- Applications



## **PROJECT OVERVIEW AND HISTORY**

- **CSERIAC and the Nuclear Regulatory Commission**
  - » Human Systems Interface Design Review Guideline (NUREG/CR-5908)
- **Project History**
  - » Document review process



## **SHORTCOMINGS OF SCIENTIFIC AND TECHNICAL INFORMATION**

- **Shortcomings of Scientific and Technical Information,  
Control Rooms Revisited:**
  - » **Changing technology**
  - » **Research gaps**
  - » **Advances in human factors research**





## **SUBJECT MATTER REVIEWED BY CSERIAC**

- **Human factors and control room design**
  - » **Display and Control Technologies**
  - » **Automation, Intelligent Aids, and Human Error**
  - » **Nuclear Power Plant Control Room Integration**



## CSERIAC REVIEW & ANALYSIS SERVICES

- Purpose
- Procedure
- Content
- Synthesis





## RESULTS OF CSERIAC's EFFORTS

- **Reviews & Analyses Final Reports:**
  - » Display and Control Technologies
  - » Automation, Intelligent Aids, and Human Error
  - » Nuclear Power Plant Control Room Integration



## CONSEQUENCES OF CSERIAC's EFFORTS

- Project Evaluation
- Further Study
- Update:
  - » Advanced Human Systems Interface Design Review Guideline
  - » The design of future control facilities



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## APPLICATIONS

- **Benefits to the design of control facilities:**
  - » Extensive review of display control technologies
  - » Expanding upon research and applications of human factors in automation
  - » Expanding upon research and applications of artificial intelligence
  - » Expanding upon research in the area of human error
  - » Expanding upon research in the area of system integration



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## **HUMAN FACTORS ISSUE IN PERSONNEL TRAINING: POTPOURRI**

- **CSERIAC support of Department of Defense personnel training**
  - Training Issues for Aircraft Automation
  - The Effects of Overtraining/Overlearning on Levels of Stress



## **STATE-OF-THE-ART HUMAN FACTORS TECHNICAL INFORMATION**

- **Exploration of literature to support defense research for the development of training programs**
  - Identify research on automation and crew member training
  - Review the issues related to automatic responses in humans





## **SUPPORTING INNOVATIVE RESEARCH**

- **CSERIAC helped to identify:**
  - Research for training crew members to interact with automation
  - Literature for the development of automaticity in personnel



## **CSERIAC SEARCH & SUMMARY SERVICES**

- **Definition**
- **Procedure**
- **Purpose**
- **Scope**



## **RESULTS OF CSERIAC'S EFFORTS**

- **Training Issues for Aircraft Automation**
- **The Effects of Overtraining/Overlearning on Levels of Stress**





## CONSEQUENCES OF CSERIAC's EFFORTS

- CSERIAC provided a firm foundation on which these researchers could develop new training programs.



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## APPLICATIONS

- **Military**
- **Industry**



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## HUMAN FACTORS IN THE DESIGN OF SYNTHETIC ENVIRONMENTS

- Task Overview
- Project Scope
- Subject Matter Addressed
- CSERIAC Search & Summary Services
- Results of CSERIAC's Efforts
- Consequences of CSERIAC's Efforts
- Applications



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## **HUMAN FACTORS IN THE DESIGN OF SYNTHETIC ENVIRONMENTS**

- **Definition**
- **Benefits**
- **Components**
- **Goals**
- **Results of CSERIAC's Efforts**
- **Consequences of CSERIAC's Efforts**
- **Applications**





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# **HUMAN FACTORS IN THE DESIGN OF SYNTHETIC ENVIRONMENTS: TASK OVERVIEW**

- **CSERIAC support of the Small Business Innovative Research  
Program**

- » Intelligent Information Presentation for Helmet Mounted Displays in  
Synthetic Environments
- » Force Tactile Feedback for Virtual Reality Environments
- » Interaction with 3-D "Virtual" Environments



## **STATE-OF-THE-ART HUMAN FACTORS TECHNICAL INFORMATION: PROJECT SCOPE**

- Exploration of literature to support research for innovative concepts to solve defense-related scientific or engineering problems.
  - » Explore the presentation of tactical information
  - » Review how humans use tactile feedback in manipulating controls and displays
  - » Investigate how humans interact with 3-D virtual environments



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## **SUPPORTING INNOVATIVE RESEARCH: SUBJECT MATTER ADDRESSED**

- **CSERIAC identified:**
  - Research on the presentation of information for Helmet Mounted Displays
    - » Pilot information load
    - » Information usage
    - » Hardware constraints
  - Literature on force tactile feedback
  - Information for the creation of natural and realistic environments.



## CSERIAC SEARCH & SUMMARY SERVICES

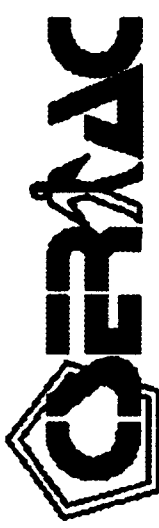
- **Definition**
- **Procedure**
- **Purpose**
- **Scope**



## **RESULTS OF CSERIAC's EFFORTS**

- Intelligent Information Presentation for Helmet Mounted Displays in Synthetic Environments**
- Force Tactile Feedback for Virtual Reality Environments**
- Interaction with 3-D “Virtual” Environments**





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## CONSEQUENCES OF CSERIAC's EFFORTS

- CSERIAC provided a firm basis so small businesses could meet the research needs of the Department of Defense.



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## APPLICATIONS

- There are few limitations to the scope of CSERIAC's Research. Although the information is intended for use in aviation settings, the results can be applied to most research and development for synthetic environments.



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## **STATE-OF-THE-ART HUMAN FACTORS TECHNICAL INFORMATION**

- **Head-Up displays and tactical aircraft**
  - Explore the issues
- **Keyset usage in tactical aircraft**
  - Provide definition
- **Redesign of jet engine I/R devices**
  - Provide recommendations





## **IMPROVING THE DESIGN OF TACTICAL AIRCRAFT COMPONENTS**

- **Human Factors Issues in Head-Up Display Design: The Book of HUD**
- **Key Parameters for Avionic Keyset Input Devices**
- **Human Factors Considerations in Jet Engine I/R Devices**



## **CSERIAC STATE-OF-THE-ART REPORT (SOAR) AND REVIEW & ANALYSIS SERVICES**

- **State-of-the-Art Report**
  - Definition
  - Author Selection
  - Peer Review
- **Review & Analysis Services**
  - Purpose
  - Procedure
  - Content
  - Synthesis



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## RESULTS OF CSERIAC's EFFORTS

- **Publication of the SOAR**
- **Review & Analysis Final Report:**
  - Key Parameters for Avionics Keypad Input Devices
  - Human Factors Considerations in Jet Engine I/R Devices



## **CONSEQUENCES OF CSERIAC's EFFORTS**

- **Definition for implementing Head-Up displays**
- **Specifications for keysets in tactical aircraft**
- **Recommendations for the design of I/R devices**





## **APPLICATIONS**

- **Human Factors Issues in Head-Up Display Design: The Book of HUD**
- **Key Parameters for Avionics Keypad Input Devices Review & Analysis**
- **Human Factors Considerations in Jet Engine Installation and Removal Devices Review & Analysis**



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## **HUMAN FACTORS & TACTICAL AIRCRAFT: POTPOURRI**

- **Human Factors Issues In Head-Up Display Design: The Book of HUD State-of-the-Art Report (SOAR)**
- **Key Parameters for Avionics Keyset Input Devices (Review & Analysis)**
- **Human Factors Considerations in Jet Engine Installation and Removal (I/R) Devices (Review & Analysis)**



**ACADEMIC APPAREL RESEARCH  
TECHNICAL SUPPORT AND PRODUCTS FOR DLA**

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**Approved for Public Release: Distribution Unlimited**



# **ACADEMIC APPAREL RESEARCH DOD MISSION - LOGISTICS**

- **DEFENSE LOGISTICS AGENCY CONTEXT**
- **Maintain the Domestic Apparel Production Base**
  - Shrinking Defense Industrial Base
  - Increased dependence on foreign suppliers
  - Dwindling surge potential
- **Develop and Maintain Surge Capability for Apparel (Military Uniforms)**
  - Develop production technologies
  - Leveraging commercial technologies
  - Modernization Issues

# **ACADEMIC APPAREL RESEARCH DOD MISSION - LOGISTICS**

- **DLA TASK COMPONENTS**
  - **Overview DLA Military Sewn Products Automation**
    - **Demonstration sites**
    - **Research projects**
    - **Academic based research**
  - **Provide Technical Research for MILSPA**
  - **Provide a Forum for Presentations of Apparel Research**
    - **DLA Researchers**
    - **Other academic researchers**
    - **Special research topics**
    - **Demonstrated industry applications**
  - **Summarize Technical Results in Proceedings and Reports**

# **ACADEMIC APPAREL RESEARCH DOD MISSION - LOGISTICS**

- **DLA TASK METHODOLOGY**
  - **Apparel Manufacture Data Collection, Analysis and Synthesis**
  - **Conference Technical Program Coordination**
  - **Conference Proceedings and Other Reports**
- **DLA TASK APPROACH**
  - **Partnership Approach**
    - **DLA - MTIAC - Researchers**
    - **Understand the common goals**
    - **Develop communication and coordination**

# **ACADEMIC APPAREL RESEARCH DOD MISSION - LOGISTICS**

- **DLA APPAREL MANUFACTURE DATA**
  - **Apparel Manufacture Worldwide Research**
    - o **Foundation for AMIS data base**
  - **Apparel Manufacturing Technology**
  - **Technical Papers**
- **RESEARCH THEMES**
  - **Apparel Manufacture Automation**
  - **Software for Apparel Manufacture**

# **ACADEMIC APPAREL RESEARCH DOD MISSION - LOGISTICS**

- **TECHNICAL RESEARCH NEEDS IDENTIFIED**

- **Domestic Capability**
- **Equipment and Process Automation**
- **Cooperative Research**

- **TECHNICAL AREA FOCUS**

- **CIM**
- **Production Methods**
- **Ergonomics**
- **Apparel Products**
- **Quality**

# **ACADEMIC APPAREL RESEARCH DOD MISSION - LOGISTICS**

- **TECHNICAL RESEARCH DIRECTIONS**
  - Apparel Research Network
  - Customer Driven Uniform Manufacture
  - Demonstration Sites
- **OTHER BENEFITS**
  - Technical Program Partnership
  - Improved Manufacturing Techniques for Apparel Industrial Base

# **ACADEMIC APPAREL RESEARCH DOD MISSION - LOGISTICS**

- **RELEVANCE TO TECHNICAL ISSUES**
  - **Industrial Surge Capability**
  - **Commercial Apparel Industry**
  - **Machine Tool Industry**
- **OTHER BENEFITS**
  - **Technical Conference Support**
  - **Methodology - IAC as Research Partner**

# **A NOTIONAL INDIVIDUAL FIGHTING SYSTEM**

**Prepared by**

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**and**

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**Approved for Public Release: Distribution Unlimited**

[The final report for this study is Limited Distribution and/or Classified.]



# CONTEXT

- THE JOINT SERVICE SMALL ARMS PROGRAM OFFICE SOUGHT TO IDENTIFY DEVELOPING SYSTEMS THAT WOULD LOGICALLY FORM A PART OF AN INDIVIDUAL FIGHTING SYSTEM
- Identify long term technological development efforts with emphasis on:
  - Survivability - improved capability of individual combatant
- Not inhibited by requirements
- Examine how identified technologies may be merged into components and systems to yield an "Individual Fighting System"

Prepared by: B. J. Tullington-Battelle/  
L. W. Williams-TWSTIAC

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# **TWSTIAC INFORMATION PRODUCT**

- **DoD S&T THRUST 5: ADVANCED LAND COMBAT**
- **DoD MILITARY MISSIONS/FUNCTIONS: GROUND FORCES/INFANTRY SYSTEMS**
- **IAC FOCUS: 21ST CENTURY LAND WARRIOR ATDS/TD**
  - **Identify related research and development projects and determine scope of the programs, objective, technical feasibility, and time schedule**
  - **Conceptualize a workable Individual Fighting System**
  - **Develop a management plan to ensure that the applicable technologies are sufficiently mature when needed**

**Prepared by: B. J. Tullington-Battelle/  
L. W. Williams-TWSTIAC**

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# **TWSTIAC METHODOLOGY**

- **METHODOLOGY**
  - **Data collection to identify related projects**
  - **Visits to program office to update information and discuss programs/problems and potential of ongoing research**
  - **Analysis of findings to assess potential of various projects**
- **APPROACH**
  - **Reviewed related TWSTIAC efforts as starting point**
    - **Future individual weapon concepts**
    - **Future alternative concepts**

Prepared by: B. J. Tullington-Battelle/  
L. W. Williams-TWSTIAC

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# **TWSTIAC METHODOLOGY**

## **(Continued)**

- **Site visits to National Labs and RD&E Centers to discuss ongoing projects -- to include:**
  - **LANL - Project Pitman**
  - **CECOM - Infantryman's Integrated Sensor System**
  - **Natick RD&E Center - Protective Equipment**
  - **Center for Night Vision - Display Devices**
  - **ARDEC - Advanced Infantry Weapons**
- **Conducted brainstorming workshops to identify likely components and system, and to assess the utility and feasibility of the concepts**
- **Identified activity proponency for system areas**
- **Outlined a plan to track technology development**

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L. W. Williams-TWSTIAC**

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# SUMMARY OF DATA

- DATA COLLECTED

- Information on projects that could impact:

- Life Support Systems: Rebreather, positive overpressure, lightweight armor, low observable shell, body function monitors
    - Fire Control Systems: GPS/NAV systems, force feedback to control exoskeleton, holographic heads up displays
    - Weaponization: Personal defense weapon, launched long range, terminal homing and variable effects weapon
    - Power Supply: Fuel cell, high density fuel storage

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L. W. Williams-TWSTIAC

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# **RESULTS OF DATA ANALYSIS**

- **FINDINGS RESULTING FROM ANALYSIS OF TWSTIAC DATA**
  - **A notional fighting system was described by systems and components, that if brought to fruition would yield a fighting system without parallel in the world**
  - **Sixteen components were identified that make up the system along with various periods for development and identification of the proponent organizations**
  - **Actions by JSSAP were suggested**

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L. W. Williams-TWSTIAC

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## **CONSEQUENCES**

- **THIS EFFORT BROUGHT THE NOTION OF AN INDIVIDUAL SOLDIER AS A "FIGHTING SYSTEM" DESERVING ATTENTION SIMILAR TO OTHER COMBAT SYSTEMS.**
- **THE SOLDIER IMPROVED PROTECTIVE ENSEMBLE (SIPE) PROGRAM IS A DIRECT SPINOFF FROM THIS EFFORT. THIS ONGOING EFFORT BY NATICK RD&E CENTER IS DEMONSTRATING SEVERAL OF THE IFS COMPONENTS, TO INCLUDE:**
  - **Integrated computer aided location and helmet display**
  - **Protective equipment**
  - **Exoskeleton development**

**Prepared by: B. J. Tullington-Battelle/  
L. W. Williams-TWSTIAC**

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## RELEVANCE TO OTHER USERS

- Natick RD&E Center: "...Impression of this report is very positive...the inclusion of the exoskeleton in the concept identified in the Battelle report goes a significant step beyond the Natick Notional System..."
- HEL: After using this analysis to evaluate a proposed concept noted: "...the Battelle report provided much of the information required for our review...In general, NRDEC...was very positive on the concept."

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TWSTIAC-9

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